AERONAUTICAL ENGINEERING REVIEW

SEPTEMBER 1951

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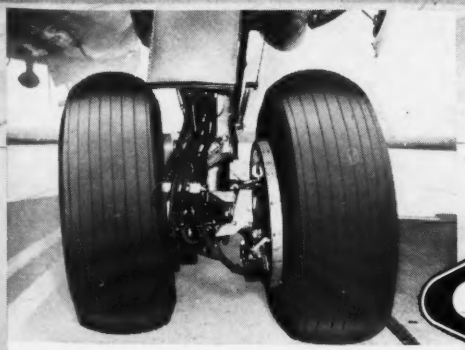

Close-Up of C-54 Cross-Wind Landing Wheels equipped with Goodyear Single-Disc Brakes. (Above) C-54 wheels castering to line up with runway as airplane continues heading into wind.

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Cover—The Navy-Douglas Skyrocket is shown after its launching from the B-29 mother ship on a flight in which unprecedented speeds and altitudes were reached. (See page 40, Douglas Aircraft Company, Inc.)

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AERONAUTICAL ENGINEERING REVIEW

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I. A. S. News

A Record of People and Events of Interest to Institute Members

1951 Annual Summer Meeting Report

Lt. Gen. B. W. Chidlaw Speaks on "AMC, The Biggest Business in the World" at the Annual Summer Meeting Dinner.

THE 1951 ANNUAL SUMMER MEETING, held in Los Angeles on June 27–28, was acclaimed as one of the Institute of the Aeronautical Science's most successful conventions. Such is the consensus of that representative group of aeronautical engineers and scientists who attended this summer meeting. Approximately 600 persons attended the technical sessions, and about 500 were present at the Annual Summer Meeting Dinner.

▸ **Technical Sessions**—Eighteen savants of the aeronautical sciences delivered papers during the course of the five technical sessions that took up all of the first day and the morning and afternoon of the second day. These sessions, which played largely to capacity crowds, covered the following topics: Aerodynamics; Stability and Control; Design; Propulsion Problems in Aircraft Design; and Design and Structures.

It is planned to publish many of these 18 papers in full as space permits in the forthcoming issues of the AERONAUTICAL ENGINEERING REVIEW or the JOURNAL OF THE AERONAUTICAL SCIENCES. Preprints of papers that are now available are listed on the Preprint page of this issue (page 124).

A more detailed discussion of the technical sessions, by Harold Luskin, is scheduled to appear in the October, 1951, issue of the REVIEW.

▸ **Annual Summer Meeting Dinner**—The Annual Summer Meeting Dinner, which brought the 2-day meeting to a close, took place on June 28 in the Embassy Room of the Hotel Ambassador, Los Angeles. Toastmaster on this occasion was the I.A.S. President, Rear Adm. Lawrence B. Richardson, U.S.N. (Ret.), who introduced to the assembled diners those persons seated with him on the dais. These included: S. Paul Johnston; Arthur E. Raymond; Dr. Clark B. Millikan; Hall L. Hibbard; John W. Reeves, Jr.; Smith DeFrance; J. B. Johnson; Major R. H. Fleet; Lt. Gen. B. W. Chidlaw, U.S.A.F.; J. H. Kindelberger; Lt. Col. Marion E. Carl, U.S.M.C.; Christopher Clarkson; Dr. J. F. Victory; J. K. Northrop; F. A. Cleveland; and E. W. Robischon.

As has been the custom at these dinners for some years, The Thurman H. Bane and The Octave Chanute awards were presented. The Bane Award was presented to J. B. Johnson, Head, Metallurgy Group, Office of Air Research, Air Development Force, Air Research and Development Command, Wright-Patterson Air Force Base, for "his outstanding contributions in the field of high-temperature materials used in aircraft propulsion units." The Chanute Award was given to Lt. Col. Marion E. Carl, U.S.M.C., Head, Carrier Aircraft Section, Flight Test Division, Naval Air Test Center, Patuxent River, Md., for "his outstanding contributions to evaluation of advanced type naval aircraft, and for a continuously outstanding career devoted to the advancement of the art and science of flying." For further details regarding these awards, please refer to page 5 of the August issue of the REVIEW.

Harold Luskin, Chairman, Annual Summer Meeting Program Committee.

Guest of Honor and principal speaker of the evening was Lt. Gen. Benjamin W. Chidlaw, U.S.A.F., then Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Ohio, and now Chief, Air Defense Command, Ent Air Force Base, Colo. In his speech, the General described some aspects of the work carried on at A.M.C., including some of the king-size headaches inherent in this logistics arm of the Air Force. Excerpts of General Chidlaw's speech will be published in the October issue of the REVIEW.

▸ **Success of Meeting**—The I.A.S. Los Angeles Section officers and committees are to be commended for their enthusiasm, diligence, and cooperation in making the 1951 Annual Summer Meeting the success it was. In particular, the Annual Summer Meeting Program Committee is to be complimented for its work in behalf of this meeting. This committee under the Chairmanship of Harold Luskin and Vice-Chairmanship of R. Richard Heppe was composed of the following members: R.L. Bliss; T. F. Coleman; H. B. Dickinson; H. S. Fischer; W. E. Gasich; F. E. Goddard, Jr.; E. S. Hodder; W. C. Hurty; H. E. Roberts; M. S. Simms; R. B. Smith; and E. J. Specht.

American Helicopter Society News

The *Proceedings* of the American Helicopter Society's Seventh Annual Forum, held in Washington, D.C., April 26–27, have been published and are now available.

This 159-page, illustrated volume, a complete record of the technical sessions of the 2-day meeting, reproduces the following papers: "Helicopter Rotor Performance Possibilities"; "The Effects of Compressibility on the Characteristics of Helicopter Rotors"; "Service Life of Helicopter Rotors"; "Design of a Rotor Kite"; "The Adaption of Jets to Helicopters"; "Demonstration Testing of Helicopters for the U.S. Navy"; "A Discussion of CAA Policies, Flight Test Procedures, and Civil Air Regulations for Helicopters"; "Testing Machines for Helicopter Transmissions"; "Some Lessons of the Liverpool-Cardiff Helicopter Service"; "Some Economic and Logistic Aspects of Helicopter Operations by the Armed Forces"; and "Economic Prospects for Large Transport Helicopters." (Copies of individual papers will not be available.) This publication also contains illustrations, figures, etc., and condensations of the Symposiums on Commercial and Military Operations.

Only a limited number of copies are available for purchase. It is, therefore, suggested that any persons desiring to obtain a copy of the A.H.S. *Proceedings* write immediately to the American Helicopter Society, Inc., 2 E. 64th St., New York 21, N.Y. The price, postage prepaid, is $3.50 to A.H.S. members and $5.50 to nonmembers.

Back volumes of the *Proceedings* for 1947, 1948, and 1949 can still be purchased. These volumes singly are priced at $3.00 to A.H.S. members and $5.00 to nonmembers. Persons who are interested in buying one or more of these back issues in combination with the 1951 volume may do so at the following rates: 1947, 1948, 1949, and 1951 volumes, $10 for A.H.S. members and $16 for nonmembers; 1948, 1949, and 1951 volumes, $8.00 for members and $13 for nonmembers; and 1949 and 1951 volumes, $6.00 for members and $10 for nonmembers.

Fourth Symposium on Applied Mathematics

The Fourth Symposium on Applied Mathematics of the American Mathematical Society was held at the University of Maryland, College Park, Md., on Friday and Saturday, June 22 and 23, 1951. The subject of the symposium was Fluid Dynamics. Attendance at each of the sessions was approximately 200. A large number of members of the Institute of the Aeronautical Sciences participated in the symposium and attended the meetings. The U. S. Naval Ordnance Laboratory at White Oak, Md., served as co-host with the University of Maryland for the symposium.

A dinner was arranged for those attending the symposium and their guests on Friday evening. At this dinner greetings were extended by Dr. Ralph D. Bennett, Technical Director of the U. S. Naval Ordnance Laboratory and Dean Ronald Bamford of the Graduate School of the University of Maryland. Professor Theodore von Kármán, Honorary President of the International Union on Theoretical and Applied Mechanics, spoke informally at the dinner.

The program of the symposium consisted of 15 papers, presented in the following order.

"Statistical Theory of Turbulence," S. Chandrasekhar, University of Chicago; "A Critical Discussion of the Similarity Concepts and Their Implications in the Statistical Theory of Turbulence," C. C. Lin, M. I. T.; "The Nonexistence of Transonic Potential Flow," Dr. A. Buseman, Langley Aeronautical Laboratory, N.A.C.A.; "Waves of Finite Amplitude in Ducts of Varying Cross-Section," Dr. R. E. Meyer, University of Manchester, England, Visiting Research Associate, University of Maryland; "Separation of Supersonic Flow from Curved Profiles," T. Y. Thomas, Graduate Institute for Applied Mathematics, Indiana University; "On the Construction of High Speed Flows," G. F. Carrier, Brown University; "An Example of Transonic Flow for the Tricomi Gas," M. H. Martin and W. R. Thickstun, University of Maryland; "Statistical Hydrodynamics," L. Onsager, Yale University; "Gravity Waves," A. E. Heins, Carnegie Institute of Technology; "Nonuniform Propagation of Shock Waves," J. M. Burgers, Technische Hogeschool, Delft, Holland; "Theory of Propellers," Dr. T. Theodorsen, Office of Air Research; "Numerical Methods in Conformal Mapping," G. Birkhoff, Harvard University; "Flow of Viscous Liquid Through Pipes and Channels," J. L. Synge, Dublin Institute for Advanced Studies, Ireland, Visiting Professor, University of Maryland; "The Method of Singularities in the Physical and in the Hodograph Plane," A. Weinstein, University of Maryland; and "Fluid Dynamics and Hydrodynamics," S. R. de Groot, Instituut Theoretische Natuurkunde, Utrecht, Holland, Visiting Research Associate, University of Maryland.

The presiding officers at the sessions were, respectively: Dr. H. L. Dryden, Director, N.A. C. A.; Prof. K. O. Friedrichs, New York University; Dr. Harry Polachek, U. S. Naval Ordnance Laboratory; and Prof. W. Prager, Brown University.

The papers presented at the symposium will be published as volume four of the *Proceedings of the Symposia in Ap-*

Lockhead Engineer Admires B-47 Model: *Clarence L. (Kelly) Johnson, Chief Engineer, Lockheed Aircraft Corporation (third from left), admires a model of Boeing Airplane Corporation's B-47 during a tour of the Boeing facilities. Later in the evening, Mr. Johnson addressed the Seattle Section on "A General Discussion of Jet Fighter Operation in Korea." Shown from left to right are: Edward C. Wells, Vice-President in Charge of Engineering, Boeing; William M. Allen, President, Boeing; Mr. Johnson; and Robert E. Hage, Preliminary Design and Sales Engineer, Boeing.*

plied Mathematics by the McGraw-Hill Book Company, Inc.

S. I. Pai, A.F.I.A.S.

1951 Heat Transfer and Fluid Mechanics Institute

Universities, industry, and research centers, both here and abroad, were represented by 175 registrants at the 1951 Heat Transfer and Fluid Mechanics Institute, which was held from June 20 to 22 on the campus of Stanford University. Representatives were also present from the Office of Naval Research, National Science Foundation, and British Joint Services Technical Mission.

This meeting, the fourth in a series of such annual gatherings, was under the joint sponsorship of the American Institute of Chemical Engineers (the Los Angeles and San Francisco sections), the American Society of Mechanical Engineers (the Applied Mechanics, Gas Turbine Power, Heat Transfer, and Hydraulics divisions), and the Institute of the Aeronautical Sciences. Those educational institutions backing this project were California Institute of Technology, Santa Clara University, Stanford University, University of California (at Berkeley and Los Angeles), and the University of Southern California. Professor A. L. London, Stanford University, was the 1951 General Chairman; Prof. H. A. Johnson, University of California, headed the 1951 Papers Committee.

Eighteen papers, contributed by various domestic and foreign universities and research laboratories, were delivered during the course of the six sessions. In order of their presentation, they were: "Diffraction of Water Waves by Breakwaters," J. H. Carr and M. E. Stelzriede, CalTech; "Hydraulics Applied to Molten Aluminum," D. S. Richins and W. O. Wetmore, Metallurgy Branch, Naval Ordnance Test Station, Pasadena, Calif.; "Steady Vortex Flow in a Real Fluid," Hans Albert Einstein and Huon Li, University of California; "Remarks on the Theory for Convection in Porous Media," F. T. Rogers, Jr., Naval Ordnance Test Station, China Lake, Calif., and H. L. Morrison, North Carolina State College of Engineering; "The Mechanics of Drops," R. R. Hughes, Shell Development Company, Emeryville, Calif., and E. R. Gilliland, Massachusetts Institute of Technology; "Pressure Distributions on the Vanes of a Radial Flow Impeller," D. A. Morelli, Hydrodynamics Laboratories, CalTech; "Some Experiments on the Heat Transfer from a Gas Flowing Through a Convergent-Divergent Nozzle," O. A. Saunders and P. H. Calder, Imperial College, London, England; "The Transient Method for Determining Heat Transfer Conductance from Bodies in High Velocity Fluid Flow," C. R. Garbett, Stanford; "Heat Conduction in a Compressible Fluid," J. D. Cole and T. Y. Wu, CalTech; "The Turbulent Mixing of Co-Axial Gas Jets," Fred Landis, Stanford, and Ascher H. Shapiro, M.I.T.; "Variation of the Eddy Conductivity with Prandtl Modulus and Its Use in Prediction of Turbulent Heat Transfer Coefficients," Rodman Jenkins, CalTech; "Internal Flow Data and a Heat Transfer Theory for the Vortex Refrigerating Tube," George W. Scheper, Jr., Gas Turbine Engineering Division, General Electric Company; "Heat Transfer, Pressure Drop, and Burnout Studies with and Without Surface Boiling for De-Aerated and Gassed Water at Elevated Pressures in a Forced Flow System," H. Buchberg, F. Romie, R. Lipkis, and M. Greenfield, U.C.L.A.; "Heat Transfer and Pressure Drop Data for High Heat Flux Densities to Water at High Sub-Critical Pressures," Warren H. Rohsenow and John A. Clark, M.I.T.; "Liquid Superheat and Boiling Heat Transfer," B. R. Mead, F. Romie, and A. G. Guibert, U.C.L.A.; "A Theory of Unstable Combustion in Liquid Propellant Rocket Systems," Martin Summerfield, Aeronautics Publication Program, Princeton University; "Transient and Steady State Heat Transfer in Irradiated Citrus Fruit," H. F. Poppendiek, University of California; and "Evaporation from a Plane Boundary," Maurice L. Albertson, Colorado A. and M. College.

Preprints of the above papers are said to be still available. They may be obtained at $5.00 per set from the Stanford University Press, Stanford, Calif.

Tentative plans have been made for conducting another Heat Transfer and Fluid Mechanics Institute in 1952. Dean L. M. K. Boelter, U.C.L.A., who was this year's Vice-Chairman, has been appointed General Chairman for 1952. Dean Boelter has asked Prof. V. A. Vanoni, California Institute of Technology, to head the 1952 Papers Committee. Any suggestions for papers should be addressed to Professor Vanoni. The time and place for next year's meeting have not been definitely settled. However, it may be held on the U.C.L.A. campus either late in June or early in September, 1952.

Necrology

William S. Friedman

William Stefan Friedman, A.M.I.A.S., was killed on June 15 in the crash into Long Island Sound of a Lockheed F-94 in which he was riding as passenger during a demonstration of new equipment to members of the Aviation Writers Association.

Mr. Friedman, known as "Blimp" to his intimates, was born in New York City on November 21, 1912. From 1925 to 1928, he worked with the D. & H. Flying Service, Sound Air Service, Empire Flying Circus, and Gates Flying Service. For the next two years, he was with Curtiss-Wright Corporation and in 1931 became an Aviation Reporter for the *Brooklyn Eagle*. The following year, he worked as Aerial Photographer for Photo News Corporation. From that time until 1940 when he first came to the Institute of the Aeronautical Sciences as News Editor of the Aeronautical Review Section of the Journal of the Aeronautical Sciences, he was connected with the Chamberlain Flying Service, Hanzlick Flying Service, Stinson School of Aviation, and *Contact*, an aeronautical newspaper.

Since leaving the employ of the Institute over 9 years ago, Mr. Friedman remained in the technical writing field of aeronautics. During 1942 and 1943, he was Technical Editor of *Air News* and Managing Editor for *Air Tech*. For the next 3 years, he served with the U.S. Army Air Force's Training Aids Division and as a T-2 operative working out of Wright Field. After his military discharge, he became Technical Editor of *Air Force* and at the time of his death was the owner of *Aircoverage*.

He is survived by his widow, the former Alice Stenzler, and two young children.

Captain Robert R. Roy

Captain Robert Raymond Roy, U.S.M.C., T.M.I.A.S., was killed earlier this year in an airplane accident in Virginia. He was 30 years of age.

Captain Roy, whose home was in Yakima, Wash., attended the Seattle (Wash.) College from 1939 to 1941 and majored in aeronautical engineering. He left there to enlist in the Naval Aviation Cadet Program and, after qualifying as a Naval Aviator, was commissioned in the U.S. Marine Corps on July 1, 1943. He was assigned to Fighter Operational Training and then was sent overseas early in 1944 for combat duty in both land- and carrier-based squadrons. From 1945 to 1948, he was a member of Naval ferry squadrons and Assistant Engineering Officer for carrier-based fighter squadrons. In 1948, he was selected to receive training

(*Continued on page 36*)

The Question of Security

?

Any technical society that is dealing primarily with matters of direct concern to the national defense today finds itself firmly impaled on the horns of dilemma. On one side is its normal obligation to service its membership with worth-while and current technical information in its fields of interest. On the other is its obligation to the country as a whole to avoid disclosures of any kind which might provide "aid and comfort" to a potential enemy.

In peacetime, the Institute never has had much of a problem to sort out the proper from the improper for presentation in its meetings and publications. Most of our papers have dealt in scientific fundamentals rather than with specific items of hardware. We have always felt that the utmost possible dissemination of basic scientific information makes for the greatest possible progress in the design of aircraft engines and components. It is our job to get as much information of that nature into the hands of our members as rapidly as possible.

Anyone, of course, can have access to I.A.S. publications. With few exceptions in the past, no security provisions were imposed at our general meetings. We have always felt that we could count on the native ingenuity of U.S. designers to apply basic information rapidly and effectively to keep U.S. aircraft in the front rank of the international parade.

During World War II, the Institute ran head on into the security problem. The supply of good papers dwindled and certain meetings were either canceled or held under "restricted" conditions. Between 1946 and 1949, however, the situation eased; but in the growing crises of 1950 and 1951, we are rapidly getting back into a regime of wartime restrictions. As many of you know, it has recently been necessary to require clearances to attend some meetings or to receive the printed records of

Editorial

such meetings (e.g., the National Propulsion Meeting at Cleveland, March, 1951). Also, on an increasing scale, papers on many subjects are being refused, withdrawn, or subjected to last minute emasculation.

Now, we will be the last to argue against the necessity of such things under present conditions. As responsible citizens, we are aware that considerations of national security may take precedence over our normal obligations to our membership. (We do not share, for example, in the hue and cry raised currently over alleged abrogation of the so-called "freedom of the press." We feel that the Armed Services and the press have occasionally exhibited a shocking disregard of the national interest in the realm of technical disclosure.) But we do feel that present techniques of security control, at least in the scientific and technical fields, leave much to be desired.

The main difficulty lies in the lack of a central agency willing or competent to rule on the release of technical material or to pass on the qualifications of individuals to receive or to discuss classified material under I.A.S. (or other similar) auspices. The Espionage Act of 1917 (amended March, 1940) is the "Bible," but there are as many interpretations as there have been of Holy Writ. Not only do the views of each of the Armed Services vary, but also the understanding, the competence, the personal feeling, and even the state of health of every individual in every echelon introduce further variables. The complexities increase as X^n, where n represents the number of individuals involved in any given transaction. We have had several cases recently where papers have been prepared for presentation at I.A.S. meetings with the approval of reasonably high local authority, only to be rejected at the last minute by higher authority, applying a different interpretation of the same rules. This, of course, is wasteful of time and effort on the part of authors and confusing to program planners.

Also, it is extremely difficult to establish proper channels through which individuals may be cleared to attend restricted technical meetings or special tours of research or other facilities organized under Institute auspices. A search through the security records of four or five separate agencies is often necessary to establish clearance for individuals. During the past year, a number of embarrassing situations have arisen in which obviously trustworthy individuals have been disqualified simply because their official dossiers were not filed in proper places.

Here again, we are not advocating any relaxation in requirements. In fact, we believe that all possible means should be used to make it more difficult for unqualified individuals to have access to "sensitive" technical information. We would favor the imposition of *tighter*, but *more rational*, controls.

We feel that the Department of Defense might give some thought to simplifying the problem. Clarifying the directives that apply to essential technical information (as contrasted to the ordinary run-of-mill "public relations" type of material) would be a first step. It might then set up some central clearing agency for the certification of technical information and provision for proper security credentials for individuals. Such a move would relieve the several Departments of the Armed Services many man-hours of labor now necessary to make elaborate cross checks on individual clearance requests and could eventually lead to a rational and uniform policy covering the release of technical material for the use of all technical societies. The societies would then be in a better position to service their members with the kind of material that is essential to them if they are to perform useful functions in the present national emergency.

S. P. J.

Considerations in the Design and Installation of Cockpit Check Lists, Placards, and Manuals

DAVID H. KAPLAN*

Introduction

Jerome Lederer

Director, Flight Safety Foundation, Inc.

Check Lists: "You Can't Remember All You Know"

A great deal of research has been accomplished on the problems of vision, readability, and lighting. The Flight Safety Foundation thought that some of the more pertinent data should be brought together for the consideration of engineers who design cockpit check lists. Accordingly, David Kaplan, a graduate aeronautical engineer, experienced in cockpit design, and President of Convertawings, Inc., was asked to prepare this study. The Flight Safety Foundation hopes that it will lead to a well-organized procedure for the design of better check lists.

THE PURPOSE OF THIS ARTICLE is to provide a starting point for the further study of this subject that merits considerable thought, experimentation, and practical application. A check list intelligently designed, when properly used, should help considerably in bridging the gap between man and mechanism and thereby assist in eliminating the accidents attributed to pilot error or poor cockpit layout.

The designer has a tendency to look on the pilot as a man of special qualities and above normal human error. He may be given a false impression of the success of his design from an operational point of view by the limited outlook of highly competent factory test pilots. Many times in the design rooms of an aircraft plant the expression is used, "Well, if he does make that mistake he shouldn't be flying a plane." The designer then lays out a switch panel or locates a control in a place that permits incorrect operation or requires unnatural concentration to operate properly.

This attitude has contributed to extraordinary requirements for training of flight crews and has placed an abnormally high order of responsibility on their shoulders.

A pilot cannot remember all he knows, so, like the housewife on a shopping trip, check lists are needed to assist the pilot in cockpit procedures. The mere presence of the check list is not sufficient insurance that the pilot will not make mistakes. Some pilots regard the use of the check list or the reliance on the check list as an unnecessary crutch, a sign of weakness, an indication of pilot incompetency. In private flying, the inexperienced pilot often feels that the use of a check list might lead his passengers to think that he does not know his job. Transport pilots, for the most part, tend to take a more objective attitude.

Unfortunately the check list is sometimes looked upon as a device to be used only for training pilots and checking out pilots in new aircraft. Few private pilots employ check lists routinely, and when they do, they are usually makeshift. Check lists come with all military aircraft, but their use is not always guaranteed, particularly in smaller aircraft and single-seat machines. This defeats one of the primary purposes of the check list. The check list is useful in helping a student or a pilot operate unfamiliar equipment, but its most important function is to reduce the chances of operating error by providing a constant reminder to the pilot of the necessary steps in a cockpit procedure. He should be sold on the idea that at some time in his career fatigue, worry, illness, or even pleasure may create absentmindedness or lack of attention and that the habitual use of a check list may then carry him over a dangerous situation.

A constant reminder may not necessarily be required for ordinary operations in a simple plane when the pilot is concentrating on familiar procedure and that alone. However, after a lapse in flying or during times of stress and fatigue, emergency, or even slight distraction, and especially for aircraft requiring the checking of many items, it is vitally important that the pilot be provided with a guide in the form of a rigorous check-list drill to protect himself and his passengers from inevitable human errors. The only way that this drill can be established to serve under these special conditions is for it to be practiced consistently during normal routine flying. Reading off the check list must become as much a part of flying as throttle operation. The more hectic or hurried the situation, the more careful and deliberate should be the use of the check list.

The check list is an aid to close the gap between the complex requirements of the machine and the natural limitations of the pilot.

A problem associated with the use of check lists is checking without close concentration on the item being checked. A pilot may "parrot" the list instead of "thinking" it. This usually causes error in instruments, controls, or switches that are inadequately designed. Examples of this are the misreading of altimeters and fuel valve handles. Many pilots have had experiences

* Consultant, Flight Safety Foundation, Inc., and President, Convertawings, Inc.

of the type where they say "fuel on," touch the fuel valve that was pointing to "off," and proceed to start engines. Difficulty may be due to lack of concentration on the item being checked because of preoccupation with other problems or from force of habit of assuming the reading is normal.

Some Fundamental Considerations

In preparing check lists, there are several fundamental considerations that determine the basic design or arrangement. These are:

(1) Is the equipment designed for one-, two-, or three-man operation?

(2) Will the airmen using the equipment have any reluctance to use check lists?

(3) What distinctions should be made between the check lists that are used routinely and the expanded type of check lists that are designed for emergencies?

Single-Place

In aircraft designed for operation by a single pilot, it is important to locate the list and arrange it so that it is natural for the pilot to make use of it. To make it a natural part of his flight technique, he should not have to turn, reach, or adjust to see his check list; it should be located whenever possible with his other flight instruments. This assists in overcoming a possible psychological block against the use of the check list in that it implies pilot incompetency (especially in private aircraft where passengers can observe the pilot). The pilot should be able to see and use the check list without having to reach behind the seat for it, turn knobs to locate the necessary procedure, or request a passenger to read it off to him. However, a professional looking device that requires some manipulation to operate should be acceptable if a compromise is to be made. In the case of single-pilot aircraft, the single-word type of check list such as gas, undercarriage, flaps, etc., is sufficient and most effective.

Two-Place

Where there are two or more men present in the cockpit, the omission of items on the check list can be avoided by integrating the check list with cockpit procedure through the use of the "challenge and response system." The copilot reads each item from the list, and the pilot responds with the setting of the control or switch—i.e., challenge, "cowl flaps"; response, "trail." This provides a double check of the items, as well as a check on whether there is actual concentration on the item called off where the item is visible to both men.

Who Should Design Check Lists

The check list should be designed by specialists in cockpit design and not by the individual design groups in the engineering office. A cockpit designer is responsible for coordinating the installation of cockpit controls and equipment and providing for optimum safety and ease of operation. This job should be done by an engineer either with experience as a pilot or with the close cooperation of experienced pilots. The designer of the cockpit should consider the layout of the cockpit in relation to the requirements of the check lists.

Problems of proper form, lettering, lighting, wording, and location should be solved after a careful study of the psychological data on these subjects. It is one of the purposes of this report to provide a digest of the available data on these subjects to facilitate the intelligent design of check lists without resorting to extensive research into psychological reports. The results of many of the researches into these fields are not conclusive in all cases, but certain trends have been established which are of definite help to the designer.

Experienced pilots may consider some of the following comments so obvious as to be unnecessary. However, knowledge of the design of check lists is needed by engineers who have little experience in flying. Therefore, obvious items are included.

Data and Requirements

Fundamentally, the check list is not an instruction manual. The routine type of check list should not be designed to describe to the pilot how to operate the aircraft. That is the job of the instructor and a flight manual. The "routine" check list should merely give the pilot a rigid guide to follow in performing a sequence of operations. It should be designed for maximum legibility—i.e., *ease of reading for accuracy*. The wording should be extremely brief; perhaps a symbol could replace a word. The purpose of a check list is to give the pilot's memory a boost so that he will not forget necessary functions such as lowering landing gear, carburetor heat, flaps, etc. The requirements of a successful check list or checking system should be borne in mind from the very outset of cockpit design. The expanded type of check list used for unusual or emergency pro-

Fig. 1.

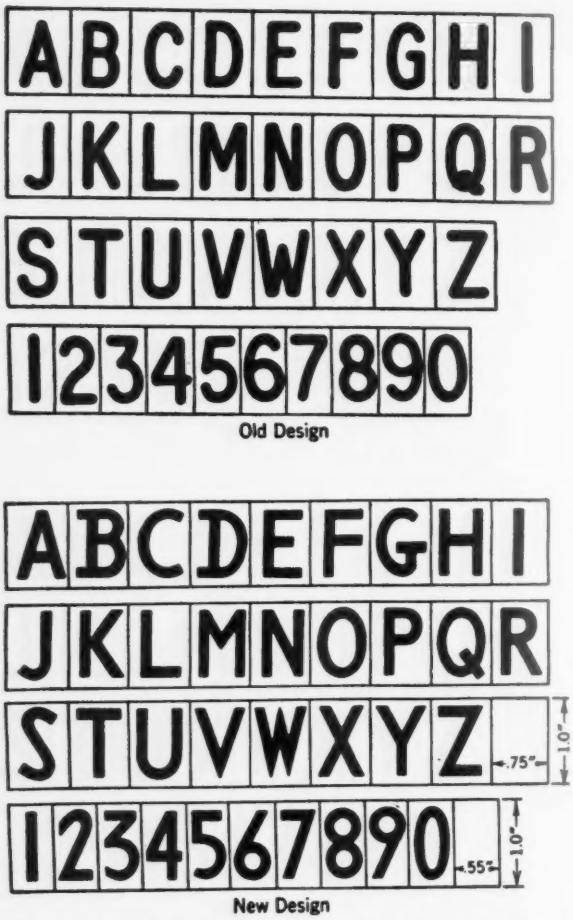

FIG. 2. (*top*) Old design of conventional block printing.[12] (*bottom*) New design of block printing for maximum legibility.[12]

cedures should contain descriptive phrases to show what to do. It should be designed for legibility *and* readability—i.e., *ease of reading with speed*.

Location

The ideal place for the check list is ahead of the pilot and so located that his eyes have an easy opportunity to look out the windshield (i.e., use split vision). The instrument panel is satisfactory if space permits and eases the lighting problem. A successful type of take-off and landing check list has been used by the Navy in single-seat fighter aircraft. This consists of a small tablet mounted inside a conventional instrument case (Fig. 1). The instrument is equipped with a knob similar to the set knob on an altimeter. One side of the tablet is for the take-off, and the other side is for the landing list. This device is located among the flight instruments and therefore cannot be overlooked easily. The pilot is required to flip over the tablet to the proper list. Turning the knob is in essence reaching for a check list, and this would be a point against the use of this sort of device in a civilian, if not in a military, aircraft.

Some check lists are the same for take-off and landing. An example would be:

Take-Off and Land
- Mixture
- Heat
- Flaps
- Brakes
- Wheel Locks

This type of list does not answer the important requirement of the check list. It does not provide a rigorous step-by-step procedure that the pilot must follow. The order with which operations are considered is just as important as the actual mention of the item.

If a situation requires no changes to be made, a rapid scrutiny of the instrument or control will suffice. If, however, a change in setting is required, then the check list should emphasize the proper new setting, as well as naming the item to be checked or altered.

Legibility

One of the most important requirements of the check list when it is located on the instrument panel is legibility. It is going to be read from farther away than a check list held by hand, and it will be subjected to cockpit instrument type of lighting and vibration (especially with a rough engine). The check list should combine all features that are desirable to ensure good legibility. It must, of course, be expected that in a practical design many of these features will have to be compromised. Nevertheless, a designer of check lists should know all the factors that affect legibility.

Legibility is closely tied to visual, acuity, and the factors that improve one will also improve the other. The following important conditions affect visual acuity.

(*1*) *Brightness.*—Brightness of the color with reference to its background. It should be pointed out that combinations that give one condition of contrast under day vision give a completely different condition under night vision.

(*2*) *Visual Angle.*—This is, of course, affected by size and distance. In the case of the check list, this must be conditioned by the distance involved. The distance should be great enough to reduce the necessity of requiring the pilot to refocus his eyes when shifting from outside view to instruments to check lists. The distance to the check list should be roughly the same as the distance to the instruments.

(*3*) *Time.*—Length of observation interval. The longer the eye observes an object, the longer it has properly to focus, resolve, and record what it sees. This time requirement should be as short as possible.

When considering the problems of acuity, it is well to note some significant facts about vision when reading instruments and check lists. The nature of vision itself is too complex a subject to be discussed in this report, but certain peculiarities and limitations should be noted to aid the designer in arranging information for visual observation so that it will not be misinterpreted because of human limitations.

An important feature of visual mechanism is the eye's inability to see while it is moving. The eye flits from

point to point but sees only when it is at rest. Normal reading consists of a series of jerky movements while the brain organizes the series of brief observations into a mental picture of the word, phrase, and sentence. Psychologists refer to these motions of the eye while reading as saccadic movements.

The time required for the eye to check a simple visual pattern as it shifts from place to place to check instruments or read a check list is on the order of 0.50 to 0.84 sec. per pattern.[10] Considering the rates at which modern aircraft travel, it is obvious that anything put in the cockpit which requires more than the recognition of a simple pattern to interpret constitutes a hazard to safe flight from the standpoint of the collision hazard and operation on take-off and landing.

Since the panel check list is usually limited to a series of single words, the designer need not be too concerned about reading speed as much as about legibility.

In the panel type of single-word or phrase check list, the use of capital or upper case lettering is desirable because of superior legibility at a distance. Black numerals or letters on a white background are more legible, but this is offset by the problem of illumination for night operation.

The lettering in the short type of check list or placard often has been done in the past either by standard engraving machines or by draftsmen using one of the mechanical lettering devices such as a Leroy Guide. These methods produce uniform lettering that is neat in appearance but which is not always designed for optimum legibility. This old style block printing is originally designed to give a uniform appearance on drawings. Lettering for optimum legibility is shown in the new design in Fig. 2.[3, 12] The difference in legibility is made up by slight changes in letters that have often been confused with one another. Examples are the contrast obtained between O and Q, C and G, B and R, etc. The alphabet shown in Fig. 2 is properly proportioned regarding line width and letter size. The line width is of great importance when considering the problem of legibility when read at night.

Night Vision

To understand the problems involved in instrument, check list, and placard illumination, the designer should understand the mechanics of night vision. This is extremely complex, but certain fundamentals can be easily shown. A knowledge of these will help immeasurably in arranging the cockpit for optimum function during day or night operation.

There are two separate sets of nerves in the eye. These are referred to as rods and cones.[3] The rods are the nerves used during so-called night vision. The change-over occurs at approximately 0.01 foot-candles, which is the level of full moonlight. The cones are denser in the center of the retina, and the rods are denser toward the edges. This may account for one of the important differences between day and night vision. That is the change in color perception.

Green and yellow are more visible under daylight vision (cones) than any other colors. During night vision, however, the eyes are more sensitive to blues and greens. This shift in the visibility of the spectrum is shown in Fig. 3.

The most significant thing about this limitation which is important to the cockpit designer is the fact that it makes it extremely undesirable to employ color for any kind of cockpit indication, reference, or guide. Operating under night sight is likely to cause mistakes and accidents, since there is an inability to perceive color properly. This would eliminate color for check lists, as well as proposals to color handles so as to simplify cockpit drill and checking.[7]

The next thing to consider regarding the use of the eye at night is the problem of dark adaptation. This concerns the length of time required to pass from a state of daylight or cone vision to a state of night or rod vision. The first 8 or 9 min. after passing from bright light into darkness or semidarkness, the visual threshold drops rapidly. The initial rapid rate is due partly to the dilation of the eye. The rate then slows down, and, after 10 min. have elapsed, the rate increases sharply again as the rod vision begins to function. There is no definite demarkation when one set of nerves is functioning as against the other, since there is a constant use of some of the cones during night vision and some of the rods during daylight vision. The sharp change in rate of visual threshold lowering is due to a general predominance and activation of the rod nerves (Fig. 4). Once the rods are functioning, the visual threshold continues to lower at a decreasing rate until after 30 min. the eyes have increased their sensitivity about 10,000 times over daylight vision.

Normal night operation calls for operating on night vision as much as possible to enable the pilot to make out ground contours and landmarks, and most important, to permit him to see approaching aircraft.

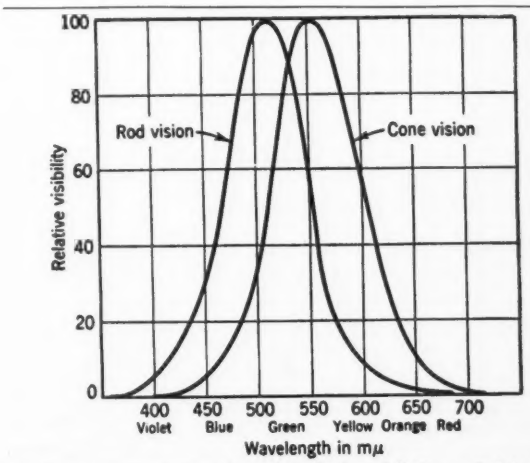

FIG. 3. These curves show the relative visibility or brightness of different wave lengths that have the same amount of energy. Notice that the eye is relatively more sensitive to longer wave lengths in daylight—that is, when the cones are working. At night, when the rods are working, the shorter wave lengths are relatively more visible. (After Troland, 1934.)

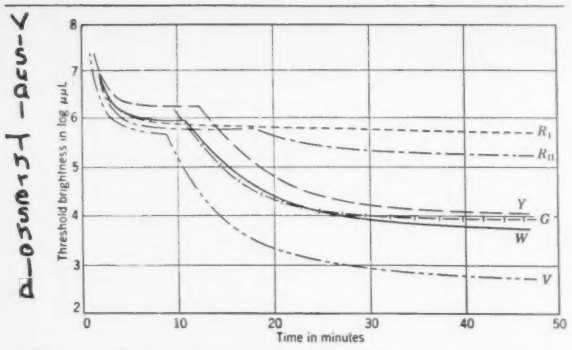

FIG. 4. Visual accommodation time when passing from very bright light into darkness. These curves show the dimmest light we can see at various times after we go into the dark. It takes about 30 min. for the eye to reach full sensitivity. Notice that we finally become most sensitive to violet (V) and that we are least sensitive to deep red (R_I) and reddish orange (R_{II}) light. (After Chapanis, 1947.)

The period immediately before landing and after take-off makes it necessary to operate with daylight vision part of the time. Landing lights, airport markers, beacons, and bright lights of the populated areas near the air terminals prevent the pilot from remaining on night vision at all times. This makes an adjustment of the instrument light intensity a necessity in order that the rate of visual threshold reduction will not be reduced by needlessly bright instrument light. The pilot should continuously dim his lights to maintain night vision as long as possible and acquire it as quickly as possible.

Since the check list should be used as a part of normal flight procedures, it will be necessary to illuminate the check list on the same circuit as the instrument lights and thus permit dimming of its light intensity. This indicates that a check list of black printing on a white background would be undesirable from the standpoint of the amount of light striking the eye to convey the necessary information. Black printing on white background, however, permits greater reading speed.

White on Black

In the case of single-word series type of check list, the reading speed is not important. Legibility is important, however, and from the previous information it can be concluded that the most desirable form would be capital letters in the form shown in Fig. 2—New Style. In addition they should be of a form that requires a minimum of illumination. This would call for white letters on a black background (Fig. 5) illuminated by a red light of controllable intensity. Further, the letters should be as large as panel space will permit.

The use of red light is dictated by the fact that rod or night vision cannot be used for observing fine details. In order to read an instrument or check list, the intensity of the light in the cockpit must be high enough to permit use of cone vision. Fig. 3 indicates that the cones are more sensitive to long wave lengths (red light) than the rods. Thus, light of long wave length can be increased to sufficient intensity for precision observation with a minimum of disturbance to the rod or night vision.

Variations in Types of Check Lists and Placards

The design of a check list is one place in the aircraft where a little startling originality is needed. Too often it is completely neglected until the last stage of a design, and then a typewritten list is prepared with only cursory thought. This sort of list is then shoved into a check list holder and brushed over by the mock-up board. Most aircraft manufacturers are coming to realize it is the cockpit that sells an airplane. The check list in turn can help sell the cockpit. The check list, if properly prepared, can bring out all of the good features of a well-organized cockpit.

Check-list information may not necessarily all be located on the check list itself. It is possible to keep the list short if information regarding such things as switch and valve positioning and lever location can be done in groups and at the controls themselves. An example of this is the recent development of a fuel control panel containing a diagram of the fuel system. Each valve and control is located in its corresponding place on the diagram. This greatly simplifies the pilot's job in an emergency, since it gives him a picture of what he is doing right at the control. In this same fashion, emer-

DC-3 2

RECEIVING
THE AIRPLANE

HEATER Water-Valves-Vent
FUSE PANEL Ckd
STAR VALVE Closed
WING DE-ICER Ckd & Off
FIREWALL CUTOFFS On
ELECTRICAL PANEL Ckd
INSTRUMENT PANEL Instrs-Warning Lights-Horn
RADIO CHECK

BEFORE START

HYDRAULIC Fluid-Pressure-Latch-Handles-Green Light-Cowls
BRAKES Set
TABS 3 Set
GAS Selectors-Amts

AFTER START

MASTER SWITCH Ships Bat.
GYRO & ALTIMETER Set
CONTROLS Free
GEAR PINS Visual Check
WEIGHT SLIP Ckd

BEFORE RUN-UP

MIXTURE Auto-rich
GAS Selectors-Amt.
CARB. HEAT Cold
ENGINES Temp & Press
HEATER As Required

FIG. 5.

gency procedure check lists can be located adjacent to the pertinent controls. An engine fire list might be located at the fire extinguisher buttons.

In most aircraft today the use of lists such as these or the use of additional panel-mounted lists and placards causes considerable space complications. In some cases additions to switch and instrument panels are impossible. If, however, attention is given to the design and installation of the check lists and placards at the preliminary design layout stage of the aircraft, there is usually a possibility of more intelligent design.

An interesting device is a check list printed on paper strips that are cemented to drums of translucent material. A light is inside the drum, and a knob is provided on the drum to select the desired list (Figs. 5 and 6). Although this list has received satisfactory comment on its service use, it might be improved. For one thing, the light should be in the instrument circuit so that it can be dimmed. In addition, the pilot must still reach for and select the proper list. This might be improved by electric actuation or by reducing the list to three: starting, take-off, and landing. The drum could then be mounted in an instrument case, and the turning could be controlled not only by the knob but also by switches on the engine oil-pressure circuit and the landing-gear warning light circuit.

The switching would be no more complicated than the ordinary landing-gear warning devices. With the weight of the ship on the wheels and the engine off, the starting check list would be shown. With the engine running and weight on the wheels, the before-take-off list would be shown. Finally, with the engine running and the gear up the before-landing list would be shown.

"Pending Items"

In the use of hand-held lists in multicrew aircraft, there are suggestions for the use of light intensity check-off of completed items. Uncompleted items would remain lit up. In one installation a toggle switch is used for each item, but the switches are not connected to any electrical source—the position of the knob or slide (Fig. 7) that is moved by the pilot shows which item remains incompleted. This provides for check-list operations that must sometimes be performed out of order, such as not lowering flaps and landing lights when air speed is too high. These items, held over because of operational limitations, require special emphasis in the list.

Emergency Check Lists on an Instrument Panel

There is no room for all the emergency check lists required in large complex aircraft. These are usually handled separately. Fig. 7 shows the ingenious use of a telephone index for this purpose.

There have been various other suggestions for unusual check-list installations that vary from punch-card type selection to small pictorial views of the aircraft with the various components called off in their proper position. These schemes are interesting, but the problems of night lighting create difficulties in practical applications.

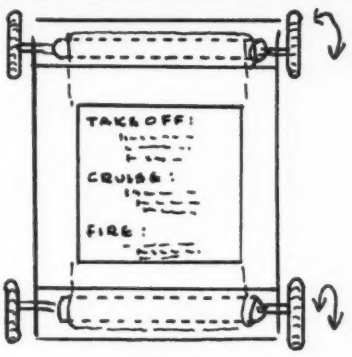

FIG. 6.

Manuals

Manuals used in cockpits or by flight engineers, navigators, etc., are necessarily longer and contain considerable written matter. Readability is necessary in addition to legibility. Manual type lists should follow certain rules of presentation which have been established by extensive psychological testing by the Aero Medical Laboratory.[1, 2] Any persons responsible for the preparation of this sort of material should bear the following rules in mind:

(1) When the relation between variables must be presented, such as in cruise-control charts, it should be done by means of tables instead of graphs. Sufficient values should be given to avoid any need for interpolation, since this is the chief source of error in reading these types of data. Tables are superior to graphs from the standpoint of speed as well as accuracy.

(2) If there is considerable material to be presented in the form of written text, use Antique (Fig. 5), Cheltenham, or Old Style type (this type is Old Style) in preference to Cloister black, Kabel light, Scotch Roman, or Bodoni, the first group being read with greater accuracy at a distance than the second group.

FIG. 7.

(3) Type size should be 10 point, although 8–12 point may be used without noticeable effect on reading speed (this type is 10 point).

(4) Lines should be 80 mm. (19 picas) for optimum reading speed. A pica is one-sixth of an inch. There are 12 points to a pica.

(5) Use capital letters and white letters on a black background for greater legibility with a minimum of illumination; use lower case letters and black on white for readability.

(6) Map lights or navigator's and engineer's lamps should provide 10 to 15 foot-candles for reading 10 point type and 15 to 20 foot-candles for reading 7 point type.

Conclusions

Consideration of the data presented and the various methods of presenting check-list information leads to certain conclusions.

(1) Check lists can prevent accidents by preventing human error if they are designed to be easily used and accepted as a regular part of cockpit procedure.

(2) Check lists must be designed and their use encouraged to overcome any psychological block against their use.

(3) Night vision requirements place the primary limitations on the mode of presenting data.

Recommendations

It is recommended that:

(1) Existing check lists and placards be examined to see if redesign can improve their utility and safety.

(2) Regulations requiring check lists and manuals be couched in terms of necessary legibility, accessibility, requirements of night vision, and other human engineering factors.

(3) Experimental work be conducted to obtain data on the utility of the methods described in this paper and explore new methods for presenting check-list data.

(4) Since the size of a check list is proportionate to the operating complexity of the aircraft, the obvious way to reduce the check-list problem is to design for simplicity.

(5) Design the check list for the requirements of night vision.

(6) Positive means be devised to recall "pending" items—items that are located in a check list at a point where they may temporarily be passed over pending the completion of some further checks or procedures. The pilot may forget to return to the pending item.

(7) The design of check lists be placed in the hands of a specialist in cockpit design who will collaborate with the designers of all the control systems in the aircraft to achieve maximum functional efficiency in the design of check lists.

This is intended as an introductory study in its field. The statements can by no means be considered conclusive, and much of the data represents opinion of the author and interested persons who reviewed the early drafts. If the material presented creates interest in, and stirs up controversy about, check lists and their use, it will have served its purpose admirably.

The author wishes to thank all those interested persons who contributed ideas, opinions, and data to this paper in the interest of flight safety.

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Control-Surface Position Feedback in Flight-Control Systems

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ABSTRACT

Present-day automatic flight-control systems are often intentionally complicated by the use of control-surface position feedback. The major advantages of constant-surface feedback as well as its inherent disadvantages are briefly discussed. The advantages treated are the reduction in phase lags and linearization of that part of the flight-control system enclosed by the feedback loop and the elimination or minimization of the possible destabilizing effects of variable surface spring constant with change of flight condition. The disadvantages treated are the possible introduction of higher frequency instabilities, the increased emphasis on the need for automatic variation of circuit parameters with flight condition, and the reduction of static gain of the system. The particular application would decide whether the advantages outweigh the disadvantages, but it has been found from experience that control-surface feedback is generally beneficial in modern flight-control systems.

INTRODUCTION

A TYPICAL SYSTEM for the control of an airplane about a single axis may be simply described by the block diagram of Fig. 1. It is often advantageous, in spite of the increased system complexity engendered thereby, to add the feature of control-surface position feedback or "follow-up." This added feature is shown by the dotted lines of Fig. 1. The consequences of the introduction of feedback into such devices as amplifiers and its general concept and meaning are adequately treated in such texts as reference 1. The concept of control-surface position feedback, however, is sufficiently important in the design of an autopilot to merit some detailed consideration within its own particular application. It is the purpose of this paper, therefore, to briefly review and outline some of the characteristics and consequences of the use of control-surface feedback in flight-control systems. Only constant negative feedback will be discussed, and the discussion will be mostly in qualitative terms with heavy stress put upon the results of experience with such systems.

CHARACTERISTICS OF SURFACE POSITION FEEDBACK

A typical flight-control system employing control-surface feedback is shown in the block diagram, Fig. 1. Using the transfer-function concept, one can readily determine that: if the inner loop is not closed,

$$\frac{\theta_0}{\theta_i} = \frac{F_2(p)F_3(p)}{1 + F_1(p)F_2(p)F_3(p)} \tag{1}$$

if the outer loop is not closed,

$$\left.\begin{aligned} \delta/\theta_i &= F_2(p)/[1 + \beta F_2(p)] \\ \theta_0 &= F_3(p)\delta \end{aligned}\right\} \tag{2}$$

if both loops are closed,

$$\frac{\delta}{\theta_i} = \frac{F_2(p)}{1 + F_1(p)F_2(p)F_3(p) + \beta F_2(p)} \tag{3}$$

$$\frac{\theta_0}{\theta_i} = \frac{F_2(p)F_3(p)}{1 + F_1(p)F_2(p)F_3(p) + \beta F_2(p)} \tag{4}$$

In the above relationships, $F_1(p)$ is a generalized transfer function that might include any number of amplifier stages and phase shifting networks; $F_2(p)$ is a generalized transfer function that includes the servomotor, control surface, and such amplifiers and phase shifting networks as might be in that particular branch; $F_3(p)$ represents the transfer function of the air frame for the particular axis under consideration; β is proportional to the portion of control-surface angle, δ, fed back into the system as shown; and θ_0 and θ_i are output and input signals concerning the air-frame axis in question.

In denoting the dynamical properties of the various parts of the system by the transfer functions $F_1(p)$, $F_2(p)$, and $F_3(p)$, it has been tacitly assumed that the system is linear. Such an assumption may be far from the truth in many practical systems where the phenomena of dead-zones, saturation, coulomb friction, speed and torque limiting of the servodrive, position limiting of the surface, and irreversibility of the servodrive-surface combination are essentially nonlinear and cannot be accurately approximated by linear systems.

On the basis of the above equations, the advantages and disadvantages of surface position feedback will be listed and then discussed. Some of the advantages are:

(1) The use of negative feedback around a portion of a flight-control system having an inherent phase lag reduces the lag in this portion. Thus, negative feedback serves the same purpose as a forward phase lead network.

(2) In the event that the portion of the system thus enclosed by the feedback contains nonlinearities, it will outwardly tend to be "linearized."

(3) The influence of the aerodynamic spring constant of the control surface on major loop response will be diminished. This is especially important in cases involving reversal of hinge moments with change of flight condition.

These are important reasons for using surface feedback in a practical flight-control system. It will be

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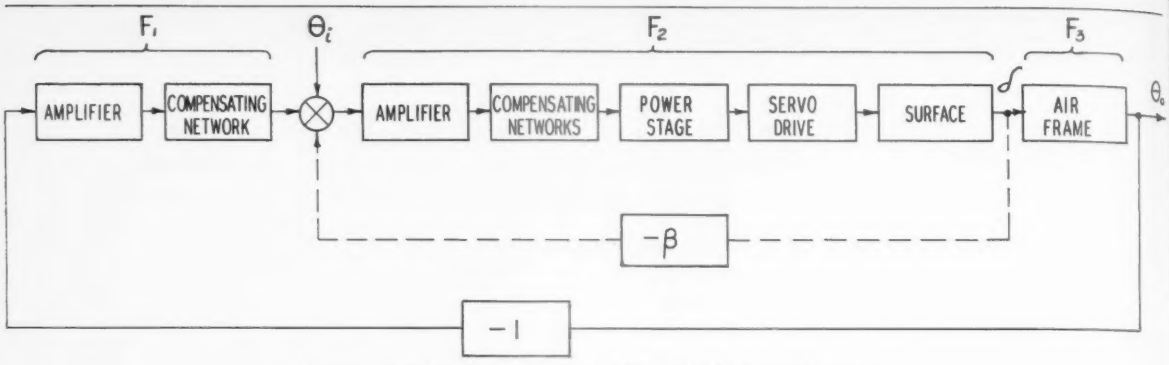


FIG. 1. Block diagram of typical single axis flight-control system.

found that, in some cases, the realization of a satisfactory system by any other means is not feasible.

On the other hand, the use of surface position feedback introduces some real difficulties and disadvantages. These are:

(1) The additional closed loop may present a stability problem when a large amount of feedback is used.

(2) The static gain of the control system is reduced.

(3) The need for changes of the parameters of an aircraft control system with flight condition or dynamic pressure for optimum response and even stability is emphasized.

ADVANTAGES OF CONTROL-SURFACE POSITION FEEDBACK

(1) *Reduction of Phase Lag*

The requirement for the reduction of phase lag in a flight-control system over some frequency range is connected with the problem of stability of the controlled airplane. Thus, if there were no inner loop, Eq. (1) would represent the operator function that describes the dynamics of the controlled system about the particular axis under discussion. Its stability would be guaranteed if θ_0/θ_i possessed no poles in the right half p-plane or on the imaginary axis. This necessary and sufficient condition is usually rephrased in terms of the well-known Nyquist criterion. A generalized equation such as Eq. (1) cannot, of course, be examined per se for stability, but it is a familiar fact that the transfer function, $F_2(p)$, which includes the servodrive and the control surface, exerts a decided destabilizing influence due to the phase lags inherent in the servomotor and the inertia of the surface at various input frequencies. In the usual aircraft control system, stability is obtained only after phase compensating networks (or other phase lead or anticipatory devices) have been added, this phase lead usually being maximized somewhere in the frequency range 0.5–3 cycles per sec.

Suppose now that the inner loop is completed so that θ_0/θ_i is represented by Eq. (4), and that

$$|\beta F_2(p) + F_1(p)F_2(p)F_3(p)| \gg 1 \qquad (5)$$

for values of $p = j\omega$ within a given frequency range. Eq. (4) can then be written as

$$\frac{\theta_0}{\theta_i} \sim \frac{F_2(p)F_3(p)}{\beta F_2(p) + F_1(p)F_2(p)F_3(p)} = \frac{F_3(p)}{\beta + F_1(p)F_3(p)}$$

and the effect of the branch, $F_2(p)$, on the dynamic characteristics of the controlled aircraft is made negligible by the use of sufficiently large feedback within the above frequency range.

Even if β is not sufficiently large, the use of feedback will decrease the phase lags due to $F_2(p)$. This result may be obtained from comparison of Equations (1) and (4).

Reduction of phase lag can, of course, also be accomplished by phase lead networks placed in the forward arm [$F_1(p)$ or $F_2(p)$, for instance] without having recourse to surface feedback. It will be found that often such a procedure is not as practical as using feedback. Thus, $F_2(p)$ may contain extremely large phase lags, entailing multiple lead networks. Since such lead networks accomplish their lead only at the cost of attenuation of the system static gain and, furthermore, since such networks are most practically of the d.c. type, it will be found that d.c. amplifying stages, with their accompanying troubles, will be necessary to keep the signal voltages at the proper levels throughout the loop and to keep the same static gain. The dynamic gain of these networks will increase with frequency, and this fact may prove destabilizing, as is evident from the Nyquist criterion point of view.

(2) *"Linearization" of $F_2(p)$*

Strictly speaking, if $F_2(p)$ contains nonlinearities such as those mentioned in a previous paragraph, mathematical analysis of the problem is either tedious or not possible at all. However, the effect of control-surface feedback on such nonlinearities contained in $F_2(p)$ may be noted from experience. A nonlinear system of the type noted may be analyzed by solving the applicable linear differential equations that will occur in consecutive time intervals, the defining equations abruptly changing with the interval. Qualitatively, it may be said that, for a given airplane departure in response to an external disturbance, control-surface feedback will tend to prolong those time intervals that express the action of the system around the feedback neutral relative to the other intervals. Since these latter intervals

serve only to introduce time lags into the system (an example is the interval for an irreversible servo-surface combination during which the surface remains fixed until such time as the input into the servomotor has reversed in sign and reached some given value), surface feedback will generally minimize instability and poor response that might result from these time lags.

(3) *Minimizing of Effect of Surface Spring Constant Variations*

The transfer function of the control surface,

$$1/(Jp^2 + cp + k)$$

is contained in $F_2(p)$, where J is the combined inertia of the surface and servodrive; c is the combined viscous damping of the surface and servodrive; and k is the combined spring constant of the surface and servodrive.

It will be a characteristic of most control surfaces that these terms are positive, and this will increase the likelihood that all the coefficients of the differential operator acting on θ_0 in Eq. (1) will be positive. This is one of the necessary requirements for stability, from the Hurwitz criterion point of view. In some applications, however, it is necessary to locate the center of pressure of the control surface relatively near the hinge line to limit the size of servomotor which would be needed to drive the control surface. As the speed of the airplane changes, the center of pressure may shift, and it is possible for it to shift to the other side of the hinge line, giving a negative control-surface spring constant. Such a change in the spring constant would be destabilizing, as is obvious from a physical consideration of the phenomenon; a given attitude error signal into the servomotor would produce an accompanying servotorque that would normally push the control surface out against a positive spring constant, the control-surface motion being consequently restrained. On the other hand, if the spring constant is negative, the same error would drive the surface out without hindrance in the desired direction until such time as the error signal subsided and, indeed, increased a certain amount in the other direction. In terms of phase lag, this would mean large phase lags due to the control surface, even at zero driving frequency.

If, however, a large amount of control-surface feedback is used, it can be seen that this effect will be minimized. Thus, the feedback acts as a positive electrical spring that is as effective as a positive aerodynamic spring, always trying to restore the control surface to its null position. The airplane attitude error will now combine with the feedback voltage, and their algebraic sum will determine which way the servodrive is to push the surface.

In this connection, surface feedback will also minimize the effects of static friction, which might be present in the servo-surface combination, and thus bring the surface back to a sharper null than it might otherwise obtain. The electrical and aerodynamic nulls should be made to coincide.

Disadvantages of Control-Surface Position Feedback

(1) *Stability Problems of "Minor Loop"*

The introduction of a large amount of feedback may also increase the general stability problem in spite of the fact that the use of feedback has minimized phase lags due to $F_2(p)$. This phenomenon is often spoken of as "minor loop" instability, although, since the major and minor loops are interconnected, the parameters of both loops are involved in the instability. This fact will be discussed with reference to Eqs. (1)–(4). Eqs. (3) and (4) are almost identical in form, and, if the coincidence that $F_3(p)$ will have a zero for the same value of p in the right half plane as does $[1 + F_1(p)F_2(p)F_3(p) + \beta F_2(p)]$ is dismissed, then if θ_0 decays with time for a step input θ_i, so does δ. This is, of course, a physically intuitive expectation for a normal airplane.

Now it has often been found that if β is sufficiently large, Eq. (4) will have a pole in the right half plane for a value of p considerably larger than that that obtained in the original instability, evidenced by Eq. (1), and a direct result of an unfavorable $F_2(p)$. When this happens, both δ and θ_0 start to increase, but inevitably some form of amplitude limiting takes place, and both δ and θ_0 execute steady oscillations at this higher frequency about a mean value, this mean value being dictated by the steady-state command θ_i. Generally, the amplitude of oscillation of θ_0 will be small.

In this case, ground checking of the autopilot will usually show an oscillation of δ at still another frequency, as dictated by Eq. (2), and at relatively larger amplitudes. The outer loop will not be closed, of course, when on the ground.

It may also happen that Eq. (2) will show an instability (i.e., when ground checking), but Eqs. (3) and (4) will not (i.e., when in the air).

(2) *Reduction of Static Gain*

A consequence of Eqs. (3) and (4) is

$$\left(\frac{\delta}{\theta_i - \theta_0}\right)_{p=0} = \frac{F_2(0)}{1 + \beta F_2(0) + F_3(0)F_2(0)\,[F_1(0) - 1]}$$

and it is generally smaller, the larger β is. Thus, suppose $F_3(0)$ includes some out-of-trim moment that must be balanced by some deflection of the control surface from its streamlined position. Some error, $\theta_i - \theta_0$, would be required as determined by the above equation, and the larger β is, the larger the required error is, unless adjustments are made in some of the other static gains.

(3) *Need for Automatic Variation of Control Parameters with Flight Condition*

The use of a large amount of control-surface feedback will generally necessitate some automatic variation of control parameters with flight condition.

As an example of what is meant, the control loop is considered to be that of pitch so that

(*Continued on page 33*)

Ejectors for Cooling a Turbojet Installation

H. C. TOWLE and F. V. H. JUDD

Republic Aviation Corporation

Introduction

THE REQUIREMENTS OF A COOLING air ejector system for a turbojet engine installation are: (1) It must provide sufficient air pumping capacity to cool the airplane structure; and (2) It must cause the minimum possible loss of available engine thrust. Ejectors suitable for such applications induce small cooling airflows relative to the primary jet flow. Extensive information is presently available for designing large secondary airflow ejectors, but data applicable to the type used for turbojet installation cooling are limited.

This paper presents a discussion of model and full-scale tests of ejectors conducted during the development of the F-84 Thunderjet.

Symbols

A = area, sq.in.
D = diameter of nozzle, in.
F = thrust, lb. (force)
g = 32.17
L = mixing length, in.
p = absolute pressure, lb. (force) per sq.in.
p' = gage pressure, lb. (force) per sq.in.
p_{sc}' = secondary suction, lb. (force) per sq.in.
V = velocity, ft. per sec.
w = flow, lb. (mass) per sec.

Subscripts

am = ambient
c = cooling flow at ejector entrance
g = gross
= engine jet
m = mixed flow
n = net
0 = free stream
s = static
t = total
1 = nozzle throat
2 = mixing chamber

Pumping Capacity

An ejector induces cooling airflow because of the high viscous shear forces set up at the edge of a free jet. As shown on Fig. 1, the jet boundary causes secondary air to flow into the mixing tube from either end. Restricting the left end of the tube will cause little suction, since the induced air can easily enter from the right end. If, however, the mixing tube is moved to the right until the downstream end is in contact with the jet boundary, it is difficult for flow to enter the right end of the tube. Restricting the left end, in this case, would result in a relatively strong suction. This simple description of ejector operation may be used in a qualitative sense, but test data are necessary for actual design.

Tests were conducted at the Republic Aviation Corporation to determine the maximum suction that could be developed by an ejector with no secondary flow. Fig. 2 gives details of the model used. The ratio of mixing area (A_2) to nozzle throat area (A_1) was 1.35. The ratio of mixing length (L) to nozzle throat diameter (D) was 4.5, which was subsequently shortened to 1.75 by trimming the end of the mixing section. The nozzle was supplied with high-pressure shop air, and the tube was discharged directly to atmosphere. Fig. 3 shows the suction developed for the two lengths.

The abscissa is the overall pressure ratio, $p_{t1}/p_{s,\,am}$, from the supply air total pressure to the ambient static discharge pressure. The ordinate, $p_{s2}/p_{s,\,am}$, is the ratio of static pressure at the upstream end of the mixing chamber to the ambient static discharge pressure.

It should be noted that the change in L/D had little effect on suction, especially for high pressure ratios. For small L/D ratios, below about 0.75, the parallel mixing section would have undoubtedly shown reduced performance, but tests were not conducted in this range.

The dotted line shown on Fig. 3 gives the theoretical performance of an ideal converging-diverging air nozzle with a discharge to throat area ratio of 1.35. The ratio of upstream total to ambient pressure is the abscissa, while the ordinate is the ratio of static pressure immediately inside the nozzle exit to ambient. At low pressure ratios, the nozzle exit velocity is subsonic and the exit static pressure is equal to ambient. At a particular pressure ratio, determined by the nozzle discharge to throat area ratio, a plane shock is expelled from the nozzle exit, and the discharge velocity abruptly increases to supersonic. With supersonic discharge velocity, the exit static pressure is determined only by the upstream pressure and the nozzle area ratio. The ratio of upstream total to exit static pressure is 5:1 for an ideal air nozzle of 1.35 area ratio operating with

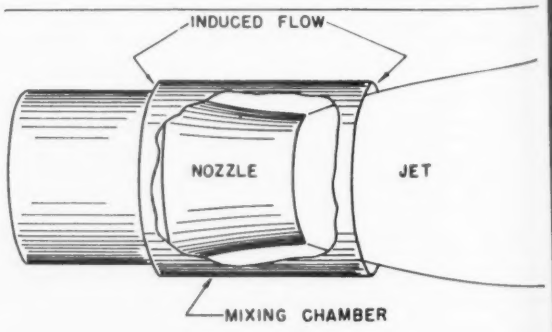


FIGURE 1. INDUCED FLOW INTO JET.

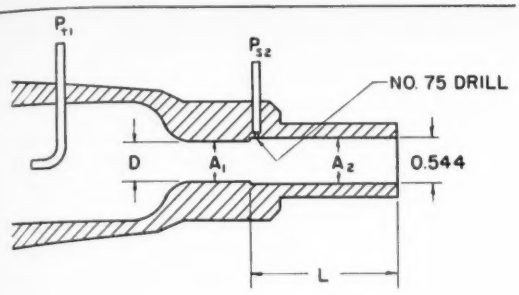


FIGURE 2: PARALLEL MIXING SECTION EJECTOR

FIGURE 3. PARALLEL MIXING SECTION EJECTOR
$A_2/A_1 = 1.35$ ○—○ L/D = 4.5
△—△ L/D = 1.78 ---- NOZZLE THEORY

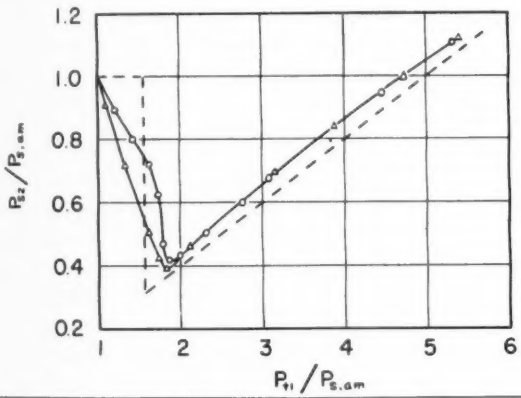
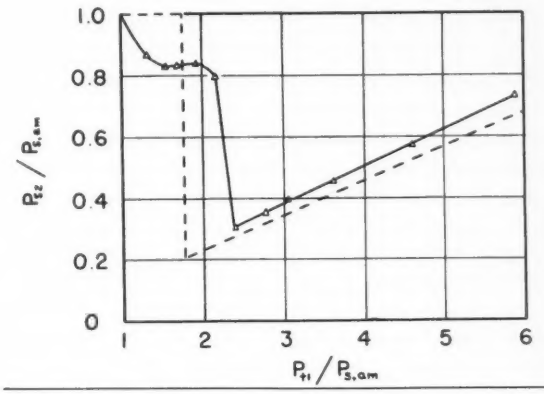


FIGURE 4. PARALLEL MIXING SECTION EJECTOR
$A_2/A_1 = 1.79$ L/D = 1.78
△—△ TEST -----NOZZLE THEORY



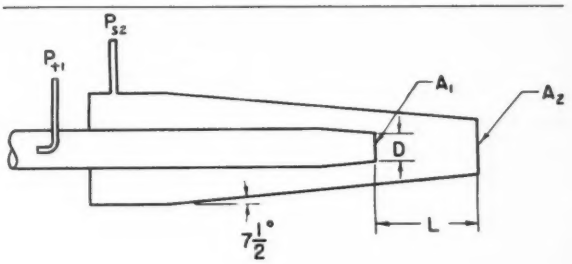


FIGURE 5: CONICAL MIXING SECTION EJECTOR USED BY TIMBIE & ALFORD.

supersonic discharge velocity. The exit static pressure, as represented by the dotted line of Fig. 3, thus remains equal to ambient until the shock is expelled, when it drops to one-fifth the upstream total pressure. The resulting curve shows a general correspondence with the measured performance of the ejector.

Since the relatively close agreement between the ejector and theoretical nozzle performance might have been coincidental, the mixing chamber was enlarged so that the area ratio A_2/A_1 became 1.79. Fig. 4 shows the results of a test of the revised ejector compared with a theoretical reversible nozzle shown as a dotted line, where $p_n/p_{s2} = 8.7$ for supersonic discharge velocities. Here again, a relatively close agreement was obtained.

The first known comprehensive tests on cooling air ejectors were conducted in 1945 at the General Electric Company by Timbie and Alford. The model for these tests incorporated a converging mixing chamber, as shown in Fig. 5. The data show that maximum suction results with no secondary airflow. Figs. 6 and 7 show typical performance with no secondary flow. The dotted line indicates the comparison for a theoretical supersonic nozzle of corresponding area ratio, and good agreement is obtained between the *maximum available* suction and the performance of a supersonic nozzle.

As opposed to the results of the parallel-walled mixing section, Timbie's data show L/D to be an important parameter in the range of from 1 to 5. There are two possible causes for this difference in behavior. The first is that the converging walls of Timbie's mixing chamber cause a portion of the jet boundary to turn and flow back upstream providing an internal source for entrained air, thereby reducing the ability of the jet to produce suction. The second is the fact that the parallel-sided mixing section limits the maximum expansion of the primary jet to that of the ejector exit area, while the conical mixing section allows the jet to expand to an area larger than the ejector exit, requiring a recompression with accompanying shock losses before discharge.

In either case, if the mixing length is so adjusted that the downstream end of the ejector just touches the jet boundary, it would appear that little backflow or overexpansion should be present. A longer mixing length, however, would be expected to cause a greater backflow or more overexpansion and consequently reduce performance. Thus, both the parallel-sided ejector and

the best L/D conical ejector, at an area ratio of 1.35, are identical in the high-pressure range, but only the conical mixing section ejector loses performance with the addition of mixing length. It appears, therefore, that the design of conical mixing chamber ejectors is more critical with regard to L/D than parallel-walled mixing chamber ejectors.

The preceding discussion has been limited to ejectors with no secondary airflow. With secondary airflow, the large suctions shown on Figs. 3, 4, 6, and 7 cannot be obtained. Fig. 8 taken from Timbie's results shows the reduction in suction caused by secondary airflow passing through a leakage area equal to approximately 5 per cent of the primary nozzle area. The effect of secondary airflow is also apparent in the results of tests of a limited number of F-84 ejectors.

One production ejector, designated "Ejector 1," had a cold area ratio (A_2/A_1) of 1.29 and an L/D ratio of 0.85. The performance of the ejector as measured on the ground and in flight is given in Fig. 9. This figure also shows test data for "Ejector 2," which was designed for a higher airflow engine but which retained the area ratio of 1.29 and L/D of 0.85. Secondary airflow for both of these ejectors was approximately 7 per cent of the primary airflow during ground runs. Similar performance curves have been obtained for many other ejectors, and all show that the ejector pressure passes through zero and becomes positive at sufficiently high jet-pressure ratios. When the ejector pressure becomes too high, inadequate cooling air will flow, and the airplane structure will overheat. It is, therefore, necessary to ensure that the zero suction point occurs at a higher jet-pressure ratio than the maximum that can be obtained from the engine installation.

From Fig. 9, ejector 1 will produce no suction at a primary pressure ratio of 3.5. An ideal nozzle designed for this pressure ratio will have an area ratio of only 1.18 or 9 per cent less than the ejector area ratio of 1.29. Other data from reduced and full-scale ejector tests show that the ratio of ejector discharge to nozzle throat area must be larger than the area ratio required for ideal expansion through the engine exhaust pressure ratio; but considerable additional test data, especially at high-pressure ratios, are required before exact design criteria can be established. Present information, however, indicates that the ejector exhaust area, as shown in Fig. 10, should be approximately 10 to 20 per cent greater than the discharge area of an ideal nozzle having a throat area equal to the engine jet nozzle area.

Thrust Loss

An accurate evaluation of the thrust penalty incurred by using an ejector is extremely difficult. An approximate method has been developed, however, which is useful in determining the difference in thrust loss between similar ejectors. The method results in the following relationship for thrust loss:

$$\Delta F_n = A_c p_{sc}' + (w_c/g)(V_0 - V_c) \qquad (1)$$

where p_{sc}' is the suction pressure (below ambient) produced by the ejector.

Eq. (1) is based upon several assumptions that are reasonably applicable to the ejector of the F-84 airplane:

(1) The ejector mixing section is of constant area.

(2) The addition of the ejector causes negligible change in external induced velocities near the jet discharge.

(3) The static pressure on the external portions of the airplane near the jet discharge is ambient.

(4) Shear forces on the walls of the ejector mixing section are negligible.

(5) Cooling air is obtained from the free stream.

Eq. (1) is derived most simply by using a one-dimensional analysis. Since the ejector area is constant and shear forces are neglected, no net axial force acts on the mixture of exhaust gas and cooling air while in the

FIGURE 6. CONICAL MIXING SECTION EJECTOR
——— TEST - - - - NOZZLE THEORY
$A_2/A_1 = 1.35$

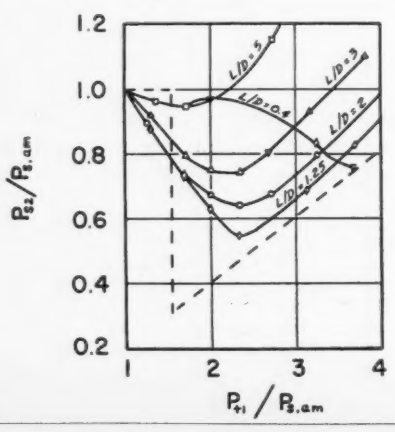
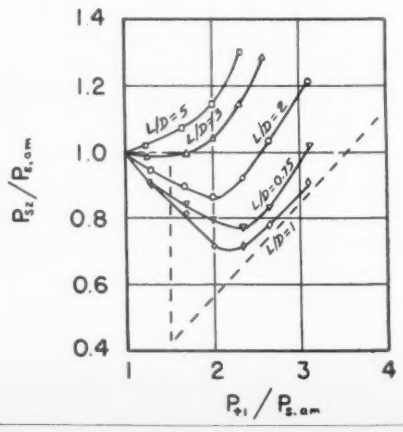


FIGURE 7. CONICAL MIXING SECTION EJECTOR
——— TEST - - - - NOZZLE THEORY
$A_2/A_1 = 1.15$



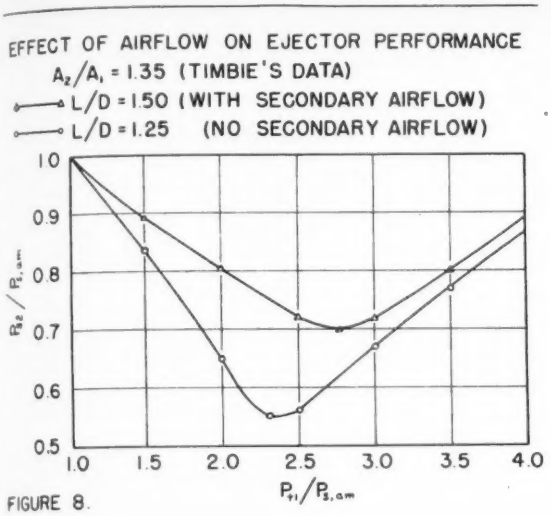
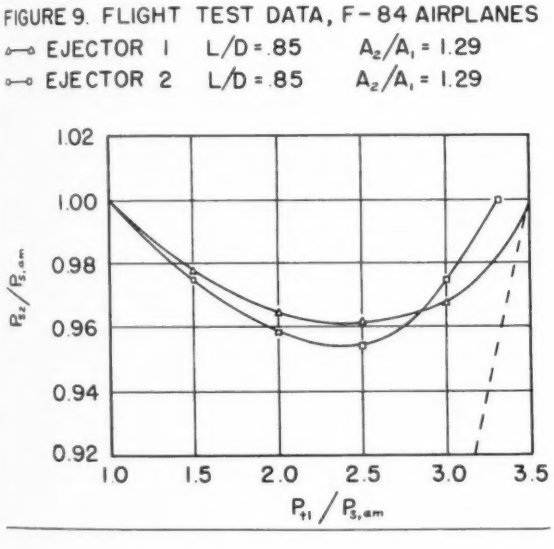


FIGURE 8.



ejector. Thus the momentum plus pressure at the ejector exit must be the same as the sum of the momentum and pressure terms of the exhaust and cooling flows at the entrance.

Thus,

$$\frac{W_m}{g} V_m + A_m p_{sm}' = \frac{w_j}{g} V_j + A_j p_{sj}' + \frac{w_c}{g} (V_c - A_c) p_{sc}' \tag{2}$$

The minus sign of the last term occurs because cooling air pressure is measured as suction.

The terms on the left side of Eq. (2) represent the gross thrust of the mixture, and the first two terms on the right represent the gross thrust of the engine without the ejector. Thus,

$$F_{gm} = F_{gj} + (w_c/g) V_c - A_c p_{sc}' \tag{3}$$

or

$$F_{gj} - F_{gm} = A_c p_{sc}' - (w_c/g) V_c \tag{4}$$

To the loss of gross thrust must be added the initial momentum of the cooling air to obtain the loss of net thrust or

$$F_{nj} - F_{nm} = \Delta F_n = A_c p_{sc}' + \frac{w_c}{g} (V_0 - V_c) \tag{5}$$

It can be concluded from Eq. (5) that an ejector causing a small thrust loss will be one having small values of suction, p_{sc}', cooling flow area, A_c, secondary airflow, w_c, and cooling air pressure losses. Since these quantities are almost completely determined by structural cooling requirements, it is evident that, unless the structure is overcooled, improvements in ejector thrust loss can be accomplished only in parallel with improvements in the structure cooling air circuit. Cooling air inlets, for instance, represent one possible source of trouble, since inlet pressure losses accomplish nothing useful in cooling the airplane structure and result directly in added thrust loss. Cooling air inlets that actually recover ram pressure should be seriously considered, although their treatment is beyond the scope of the present paper.

A series of design changes in early F-84 airplanes included the addition of a fire seal and the installation of a higher airflow engine. During an investigation of the resulting ejector thrust loss, a cylindrical ejector, attached directly to the tailpipe as a muff, was used for static testing. Various combinations of L/D and secondary airflow were investigated. The results are shown in Table I, along with the theoretical losses calculated from Eq. 5. With one exception, which may have been in error, excellent agreement was obtained.

These results, combined with those of other ground and flight tests, led to a redesign of the aft fuselage cooling configuration. Reduced cooling airflow requirements, smaller ejector area, and suction were made possible, as shown in Table II. Approximate improvements of 200 lbs. in static thrust, 9 per cent in rate of climb, and 7 per cent in range were realized by these

FIGURE 10 REQUIRED AREA RATIO FOR EJECTORS & IDEAL NOZZLES
C_p/C_v = 1.33

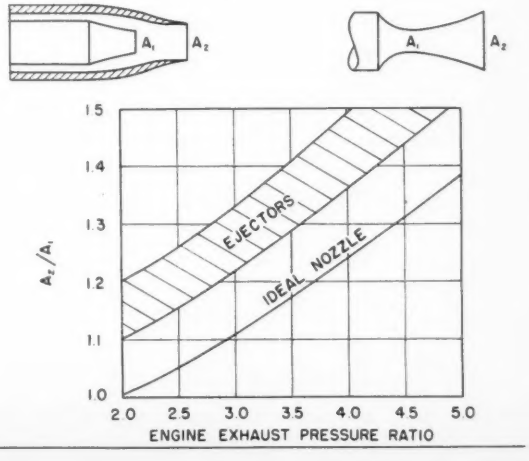


TABLE I

MEASURED VS COMPUTED THRUST LOSS
CYLINDRICAL EJECTOR ON J35-A-17 ENGINE
7800 RPM

EJECTOR	SECONDARY	MOMENTUM	PRESSURE	THRUST LOSS	
SUCTION	AIRFLOW	MV	AΔP	COMPUTED	MEASURED
IN. H_2O	LB SEC	LB	LB	LB	LB
20	3.15	11	63	52	55
52	8.45	76	161	85	100
54	5.17	29	167	138	230
86	6.66	47	267	220	250

changes. The magnitude of these improvements emphasizes the importance of ejector cooling system design and the need for comprehensive test data on suitable ejectors.

Conclusions

On the basis of the limited amount of test data presented, the following design recommendations and conclusions can be drawn:

(1) Important gains in the performance of the F-84 were realized through the use of an improved ejector and cooling configuration.

(2) More data on cooling air ejector characteristics, especially at high-pressure ratios, are needed.

TABLE II

COMPARISON OF F-84 EJECTORS

	OLD EJECTOR	HIGH THRUST EJECTOR
L/D	1.18	0.85
A_2/A_1	1.60	1.29
STATIC SUCTION, IN. H_2O	40.4	17.0
STATIC COOLING AIRFLOW, LB SEC	8.35	6.0
STATIC THRUST IMPROVEMENT, LBS	——	200
IMPROVEMENT IN RATE OF CLIMB, %	——	9
IMPROVEMENT IN RANGE, %	——	7

(3) The use of parallel-walled mixing sections simplifies the design of correct ejector length.

(4) The mixing section exit area of an ejector should be 10 to 20 per cent greater than the exit area of a corresponding ideal converging-diverging nozzle.

(5) Ejector cooling systems are similar to conventional, naturally aspirated cooling systems in that low-cooling air pressure drops and small-cooling airflows are desirable.

(6) Ejectors having minimum area ratios and suctions consistent with cooling requirements will produce minimum thrust losses.

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An Investigation of a Rotor Blade Thermal Ice-Prevention System for the H-5 Helicopter

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Sikorsky Aircraft Division, United Aircraft Corporation

SUMMARY

While this paper has particular reference to the design, construction, and test of an experimental rotor blade ice-control system for the H-5 helicopter, the method of analysis developed for determining the parameters of the system is generally applicable to the design of rotor hot-air deicing and anti-icing systems. The scope of the H-5 icing project includes: (a) heat-transfer analysis; (b) detail design of the system; (c) construction of the system components and installation on an H-5 aircraft, together with test instrumentation; (d) 10-hour flight and ground test; and (e) correlation of flight-test data with the method of analysis. The method of analysis employed was a straightforward application to the rotor blade of methods of airfoil heat-transfer analysis developed by the N.A.C.A. and A.M.C. Good agreement was obtained for dry air, and the analysis extended to wet-air conditions, which, however, were outside the scope of the test program and will form the next phase.

PART I

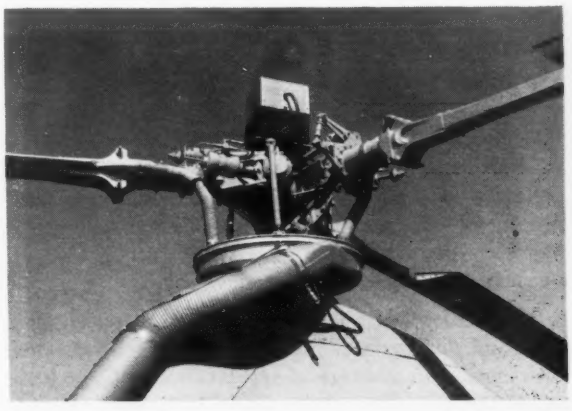
IT HAS BEEN RECOGNIZED for some time that all-weather operation of helicopters cannot be expected in the absence of an effective rotor blade anti-icing or deicing system. While the service use of helicopters has not been extensive enough for the accumulation of icing data of much significance, icing has occurred and, under certain conditions, can be expected to be much more severe than that thus far encountered. Experience with propeller icing in fixed-wing aircraft has provided evidence enough of the possible danger, and, as early as 1942, the Air Materiel Command endeavored to anticipate the problem by contracting with Princeton University for the investigation of rotor icing and the means for its control. Toward the end of World War II, icing tests of an R-4 helicopter at the summit of Whiteface Mountain, New York, conclusively demonstrated that, at least for the conditions obtaining during the tests, dangerous accumulations of ice can be encountered on rotor blades. Problems of higher priority, however, prevented adequate exploitation of the results of these investigations, and, while valuable research techniques had been developed, neither a practical ice-control system nor sufficient generalized information for the determination of the parameters of such a system for design purposes had been achieved.

Subsequent advances in research techniques were made by Princeton University, but the status of the problem remained substantially unaltered, again largely because of priority problems, until the summer of 1949, when the Air Materiel Command contracted with the Sikorsky Division of United Aircraft Corporation for the development of an ice-control system for the H-5 helicopter.

The problem had become urgent, since large numbers of H-5 helicopters and their variants had, by this time, been placed in service throughout the world. The immediate objective was, therefore, to develop a practical ice-control system for this aircraft. The long-term objective was to develop methods of analysis by means of which the required parameters for the ice-control system of any helicopter could be worked out with a reasonable degree of certainty. Achievement of the immediate objective would make possible the rapid installation of ice-control systems on service helicopters of the H-5 type, should the need arise. Achievement of the long-term objective would eliminate the excessive empiricism thus far necessary and would allow the straightforward design of ice-control systems for future helicopters or for service helicopters of types differing widely from the H-5.

PART II

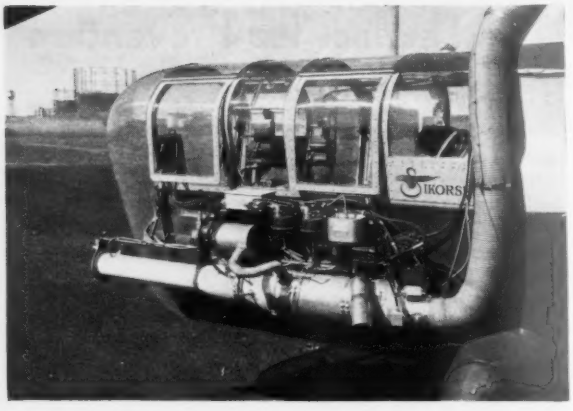
The problem had been anticipated during the design of the Sikorsky all-metal rotor blade several years previously. The leading edge of the blade, which is also the blade spar, is a single-piece aluminum alloy extrusion. Chordwise ribs are not employed in the leading edge, so that a duct is formed, continuous from root to tip, ideally suited for conducting a continuous flow of heated air from a source at the root of the blade



S-51 (XH-5) collector assembly; hot-air anti-icing installation.

Presented at the Rotating Wing Aircraft Session, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951.

* Chief Design Engineer.



View of test installation of heater in S-51 (XH-5); hot-air anti-icing installation.

to an exit at the tip. The blade retention is so designed that access to the root end of the duct is not obstructed by the blade retention. Modification of the blade for an anti-icing installation is therefore exceedingly simple, consisting only of the insertion of an insulated entry at the root and the provision of a tip exit, which is simply a rectangular orifice out in the tip fairing. These blades are standard production equipment. The modifications affect neither their balance nor their structural integrity. Thus, since the blades are by far the costliest component involved in the anti-icing system, the fact that conversion to anti-icing required so negligible a modification immediately established the necessary condition for the primary objective—namely, that modifications to service aircraft, if the installation of anti-icing equipment became necessary, should be neither extensive nor costly.

This fact formed the point of departure for the design of an ice-control system for the H-5 helicopter. Probably the most fruitful course, from the practical standpoint of the particular problem presented, was clearly to investigate the possibilities of hot-air deicing or anti-icing. The Sikorsky engineers were not confronted with a research program but with the problem of preventing dangerous accumulations of ice on the blades of a particular helicopter. It was evident that these blades were most readily adaptable to the hot-air method of ice control.

It should be noted that parallel concurrent studies of alternative methods were not made and that, therefore, no comparative theoretical assessment of alternatives was attempted before proceeding with the hot-air system. This procedure was considered to be justified, however theoretically inconclusive the evidence was in favor of a hot-air system, for practical attractiveness as well as for the following reasons:

(a) The scope of the program was severely limited as to time and funds available; hence, experimentation with more than one type of system could only be justified if the type chosen was found to be demonstrably impracticable.

(b) The difficulties of adequate theoretical treatment of certain problems in alternative systems—for instance, the optimum arrangement of electrical conductors in a blade leading edge or the efficacy of an oil film—were excessive; hence, prior analytical comparisons could be expected to be lengthy and inconclusive.

(c) The previous work accomplished by Princeton University, while inconclusive, appeared to indicate that electrical power requirements would be on the order of 60 to 70 hp. Electrical equipment for the generation of power on this order is several times heavier than the equipment required for the equivalent hot-air system.

(d) Experimentation by Princeton University with oil films had been uniformly discouraging.

(e) The most successful fixed-wing systems currently in use are hot-air anti-icing systems, and considerably more information is available on the characteristics of such systems, methods of analysis, available equipment, and solution of detail design problems than similar information on alternative systems.

(f) The hot-air system possesses a practical advantage, from the standpoint of the overall design of the aircraft, in that the same equipment is employed alternatively for cabin heating in extreme low-temperature conditions where heat for anti-icing is not required. The helicopter, it should be noted, operates well below the altitudes at which extreme low-temperature icing is encountered.

Part III

The first step in the design of the system was the determination of the required heat quantity and flow rate of heating air. The method of analysis employed was a straightforward application to the rotor blade of methods of airfoil heat-transfer analysis developed by the N.A.C.A. and the A.M.C.

The aerodynamic conditions at the airfoil are established and the local surface heat-transfer coefficients are determined for the leading edge, the laminar flow region forward of the transition point, and the turbulent region aft, using relations developed by the above sources in which the heat-transfer coefficients are functions of the absolute temperature of air and airfoil surface, free-stream velocity, airfoil configuration, air density, and the distance along the profile of the point investigated from the stagnation point. Since the aerodynamic conditions vary along the blade from the root to the tip, a step-by-step analysis was made at increments of 10 per cent of the blade radius.

The local surface heat-transfer coefficients are calculated by the simplified method of reference 4 in which the airfoil is approximated by a leading-edge cylinder of radius approximately equal to the geometrical leading-edge radius of the actual airfoil followed by two flat plates. The heat-transfer coefficients are expressed by the following:

For the leading-edge cylinder

FIG. 1
THRUST DISTRIBUTION

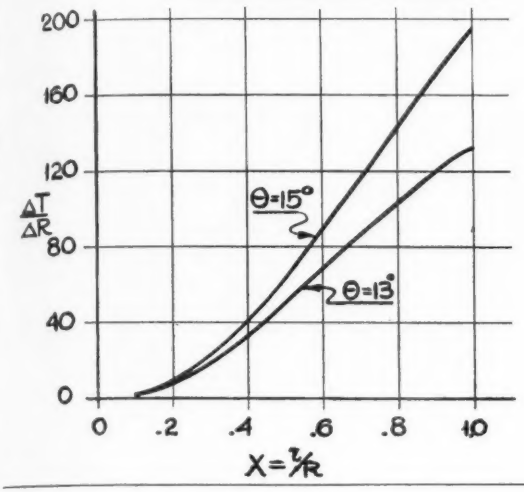
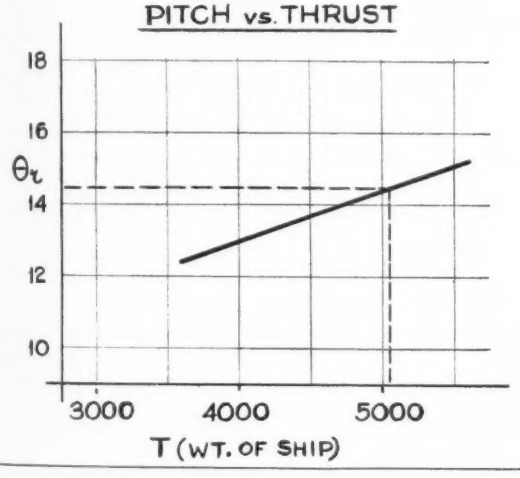


FIG. 2
PITCH vs. THRUST



$$f_c = 0.194\ T^{0.49}\left(\frac{u_\infty \gamma}{d}\right)^{0.50}\left[1 - \left(\frac{4x}{\pi d}\right)^3\right] \qquad (1)$$

where

f_c = unit thermal convective conductance between airfoil surface and air at any point X on cylinder (B.t.u. per hour ft.^{2} °F.)
T = arithmetic average absolute temperature of fluid and airfoil surface (°R.)
u_∞ = free-stream velocity of fluid (ft. per sec.)
d = diameter of cylinder (ft.)
γ = weight density of fluid at temperature T (lbs. per cu.ft.)
x = length along airfoil profile or leading-edge cylinder *measured from the stagnation point* (ft.)

For the flat plate area in laminar flow,

$$f_{c_x} = 0.0562T^{0.50}\,(u_m\gamma/x)^{0.5} \qquad (2)$$

where

f_{c_x} = unit thermal conductance between airfoil surface and air at any point x (B.t.u. per hour ft.^{2} °F.)
u_m = local velocity of fluid (ft. per sec.)

and for the turbulent flat plate area,

$$f_{c_x} = 0.524T^{0.296}\,(u_m\gamma/x^{0.25})^{0.8} \qquad (3)$$

It will be noted that the distance from the stagnation point to the point being investigated must be known, and, for the flat plate sections, the location of the transition point and the local velocity of airflow over the surface must be known. Prior determination of these values is therefore made from the characteristics of the actual rotor. The first requirement for locating the transition point is a knowledge of the section lift coefficient. The distribution of lift coefficient is therefore obtained, by conventional blade element theory, by first determining the thrust distribution (Fig. 1), integrating, cross-plotting blade angle vs. thrust (Fig. 2), and hence obtaining, for the blade angle corresponding to the known thrust, the C_L (Fig. 3), from the well-known relation

$$C_L = a\alpha = a(\theta - \varphi) \qquad (4)$$

where

a = slope of lift curve
θ = blade angle
φ = induced angle
α = section angle of attack

The second requirement for determining the location of the transition point is the section Reynolds Number (Fig. 4), which is simply calculated for any blade station and, hence, is immediately known for all the others since it is, of course, proportional to blade radius.

The transition point is located by first plotting, in accordance with reference 3, the Reynolds Number for which the flow at a given chordwise location changes from laminar to turbulent at a given lift coefficient (Fig. 7). Since the section Reynolds Number and lift coefficient are known, it is then possible to locate the transition point on the upper and lower surfaces of any blade section and, hence, to plot its location in per cent chord against blade radius. Fig. 8 shows this plot for the transition points on the upper surface.

The local velocity of airflow over the surface remains to be determined in order to locate the stagnation point and, as previously indicated, to complete the information necessary for determining the surface heat-transfer coefficients [Eqs. (1), (2), and (3)].

The method given in reference 2 is employed, from which the local velocity may be obtained from the ratio of local velocity to free-stream velocity. This ratio is expressed as[2]

$$u = v/V = K[\sin(\alpha + \phi) + \sin(\alpha + \beta)] \qquad (5)$$

FIG. 3
C_L vs X

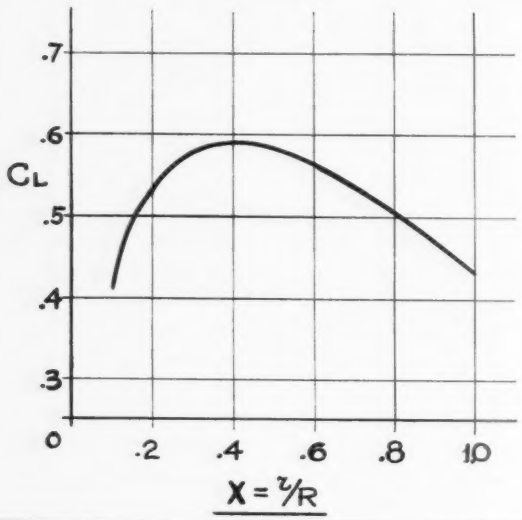
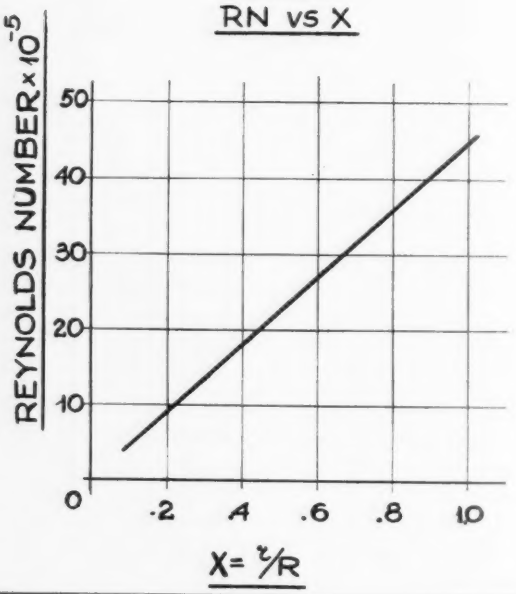


FIG. 4
RN vs X



where K, α, ϕ, and β are derived from theoretical airfoil constants given in Table I of reference 2, for the NACA 0012 airfoil. The velocity ratios at various chordwise locations are then plotted (Figs. 5a and 5b) vs. C_L so that the local velocity ratios can be determined for the particular section and C_L. By plotting the velocity ratios vs. per cent chord for various lift coefficients (Fig. 6a), the stagnation points are located, which are simply the intercepts on the horizontal axis. Stagnation point location in per cent chord is then readily plotted against C_L (Fig. 6b), providing a convenient means of locating stagnation points for sections with intermediate lift coefficients.

FIG. 5a
UPPER v/V vs X

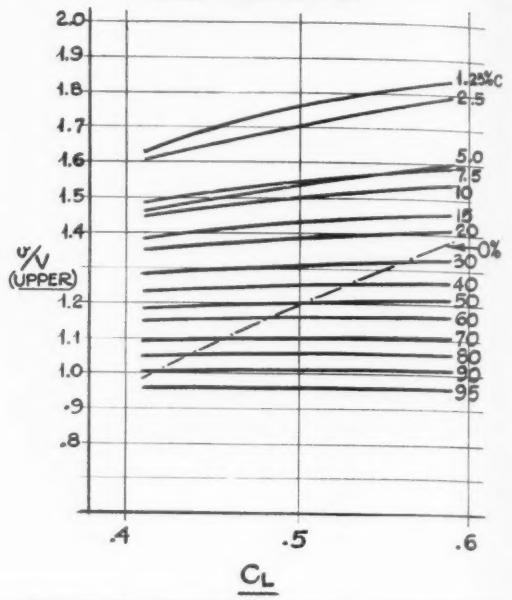
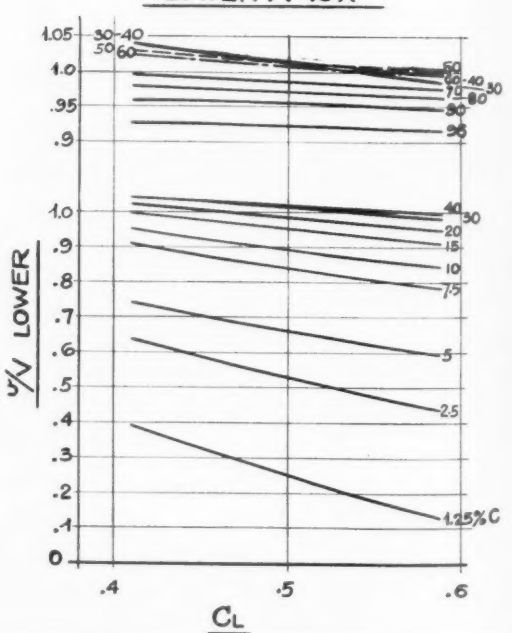


FIG. 5b
LOWER v/V vs X



The equations [Eqs. (1), (2), and (3)] for determining the surface heat-transfer coefficients may now be used. A root outside temperature and a radial rate of surface temperature decrease must first be assumed, and trial and error heat-balance calculations must be made along the blade at increments of 10 per cent of blade radius.

In passing through the blade, the heated air loses some of its internal heat to the blade spar by convective conductance. The spar in turn loses heat, in a similar

manner, to the atmosphere. The heat lost to the spar is equated to the heat lost from the spar. The heat balance is therefore written

$$Wc_p \Delta t = h_i s_i (t_{\text{int.}} - t_s) = f_e s_0 (t_s - t_\infty) \qquad (6)$$

where

W = weight flow rate of heated air
c_p = specific heat of air
Δt = internal temperature drop
h_i = internal heat-transfer coefficient
f_e = external heat-transfer coefficient
s_i = internal surface area
s_0 = external surface area
$t_{\text{int.}}$ = heated air temperature
t_∞ = ambient air temperature
t_s = skin temperature

It will be noted that in the above the external heat-transfer coefficient is the arithmetic average of the values at the beginning and the end of the blade increment considered. The values at the two ends of the segment are in turn average values calculated from the plot of f_e vs. x (Figs. 10 and 11).

It should be noted that, because of the high tip speed of the blade, the stagnation temperature of the air contacting the blade is not a negligible quantity in its effect on the internal heat-flow requirements. This temperature rise is given by the expression

$$\Delta T_r = V^2/12{,}000 \qquad (7)$$

and, at the tip, it is of the order of magnitude of 20°F., diminishing inboard proportionately to the square of the radius.

It is finally necessary to consider that portion of the heat balance in which the heated air loses some of its heat to the blade spar. Again, an initial temperature and rate of decrease must be assumed and, as indicated above, the heat balance must be determined by trial and error. The amount of heated air required to raise the blade surface temperature at the root to the assumed value is determined from the Reynolds analogy of flow friction and heat transfer by using the Nusselt Number as determined from reference 5.

The quantities involved are:

$$D_e = 4m \qquad (8)$$

$$\text{Reynolds No.} = GD_e/\mu \qquad (9)$$

$$\text{Nusselt No.} = h_i D_e/K \qquad (10)$$

where

D_e = equivalent diameter of the blade passage
m = hydraulic radius of the blade passage
G = weight flow rate per unit area
μ = viscosity coefficient

Eq. (6) may now be used to calculate the trial and error heat balance. The process is repeated incrementally along the blade from the root to the tip. Fig. 12 shows the variation in internal temperature with blade radius for three ambient temperatures.

FIG. 6a
LOWER V/V vs % CHORD

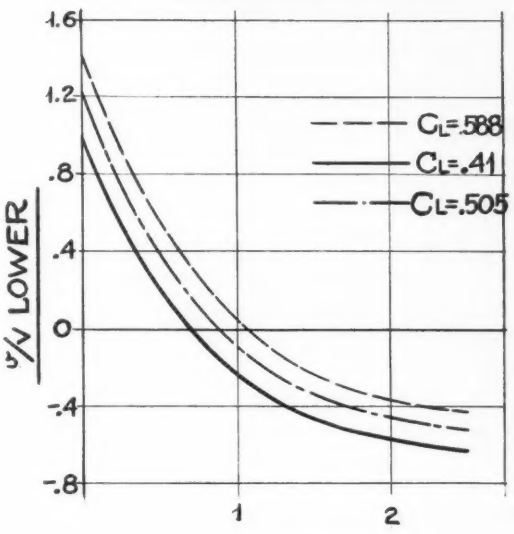


FIG. 6b
LOCATION OF STAGNATION POINT vs C_L

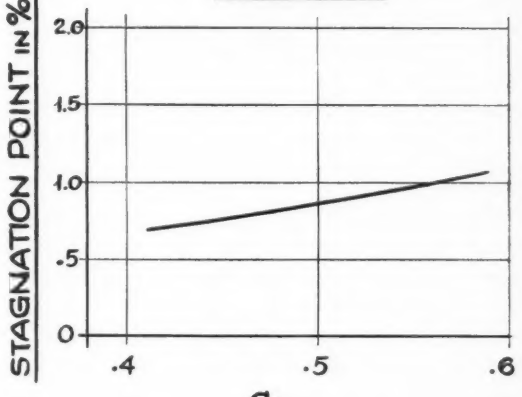


FIG. 7
VARIATION OF THE TRANSITION POINT
UPPER SURFACE ---LOWER SURFACE

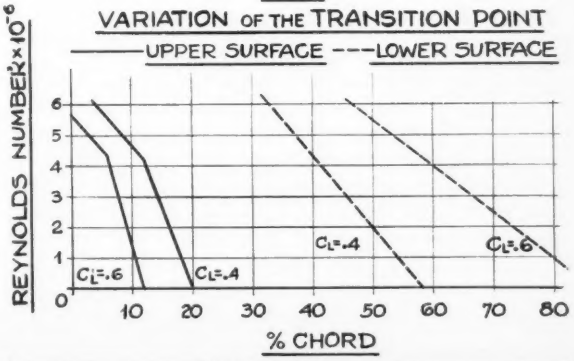
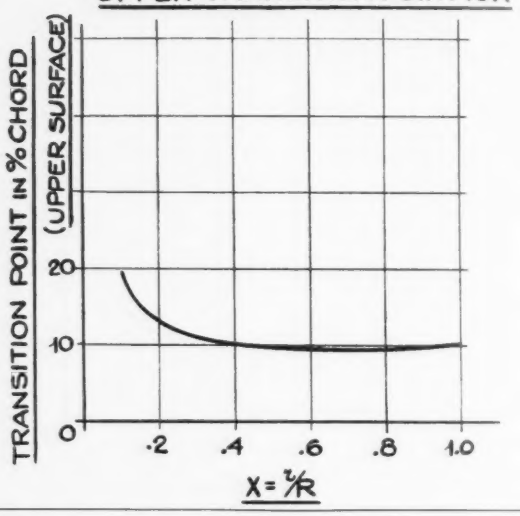


FIG. 8



The analysis was originally carried out for dry air, and it was on the basis of this analysis that the heat-source equipment was chosen. Blade surface temperatures measured in flight were checked against temperatures predicted by the method described for the atmospheric and blade-loading conditions existing during flight test. Good agreement was found throughout the range of conditions tested.

Fig. 13 presents the results of a chordwise temperature analysis at $x = 0.7$ for comparison with test results. The apparent discrepancy in the laminar flow region is accounted for by the fact that the thermocouples that were, for practical reasons of time and funds available, placed on the surface of the blade undoubtedly produced turbulent flow over the surface just aft of the leading edge. The broken line in Fig. 13 approximates the surface temperature when the laminar flow region is replaced by a turbulent flow. It will be noted that considerably closer agreement in the laminar region is then obtained.

Before proceeding to a discussion of icing conditions, it is necessary to examine briefly the factors that point up the relevance of the dry-air investigation in respect to predicted performance when icing conditions prevail. The first fact of importance is that the external heat-transfer coefficient (f_c) is only slightly affected by temperature variations, since

$f_c = f(T^{0.49})$ for the leading edge
$f_c = f(T^{0.5})$ for the laminar flow region
$f_c = f(T^{0.296})$ for the turbulent flow region

Second, the turbulent region on the airfoil more closely approaches the stagnation point because of the moisture present on the surface—a fact that tends to increase the average external heat-transfer coefficient for a given temperature. Therefore, an average f_c calculated for relatively high-temperature dry air may be used for a first approximation for icing conditions at lower temperatures.

Although the scope of the program did not include tests under actual icing conditions, these conditions were investigated analytically, since the dry air predicted performance would be affected by surface wetting and evaporation.

The phenomena existing under icing conditions may be summarized as follows: When icing conditions are present in the atmosphere, some of the moisture that impinges on the blade surface can be expected to evaporate if the surface temperature in above ambient temperature. The evaporation rate is dependent on the surface temperature, which in turn is partially affected by the evaporation rate. When all of the impinging moisture is not evaporated at the area of impingement, the problem of runback is encountered. A portion of the unevaporated moisture will run back over the colder trailing edge. The remainder will blow off into the air stream. The runback portion will form ice if the trailing edge surface temperature is below the freezing temperature.

The following representative set of values was used in the icing analysis:

Pressure altitude	Sea level
Droplet diameter	20 microns
Liquid water content	0.3 Gm. per cu.m.
Temperature	0°F.

The weight rate of water impingement and area of impingement were determined by the method suggested in reference 6. In order to find the collection efficiency, a dimensionless drop inertia quantity, K, must first be determined. This is expressed as

$$K = \frac{2}{9}\frac{\gamma_w a^2 V}{c\mu} \tag{11}$$

where

K = dimensionless drop inertia quantity
γ_w = specific weight of water, lbs. per cu.ft.
a = radius of water drop, ft.
c = airfoil chord length, ft.
V = free-stream velocity, ft. per sec.
μ = viscosity of air, lbs. per sec., ft.

For this K value, the collection efficiency, E, is then found from Fig. 3 of reference 6. Collection efficiency is defined as the ratio of the vertical distance from the chord line for which droplets of a particular K value just miss the airfoil to the maximum ordinate of the airfoil or

$$E = y_{0\text{limit}}/y_{max.} \tag{12}$$

Hence, $y_{0\text{limit}} = 0.6CE$ for a 12 per cent airfoil section, from which the area of impingement is found from the airfoil geometry.

The rate of impingement[6] is

$$M_s = 3{,}600\ EVmy_{max.} \tag{13}$$

where

M_s = weight rate of water drop impingement per ft. of span for one side of the airfoil, lbs. per hour, ft.
E = water drop collection efficiency
V = free-stream velocity, ft. per sec.
m = liquid water content, lbs. per cu.ft.
$y_{max.}$ = maximum ordinate of airfoil, ft.

It is now possible to determine whether the heat available is sufficient to evaporate the moisture on the surface, since the impingement rate, impingement area, and heat available at the wetted surface are known. The evaporation rate is given by[7]

$$e = 0.62Af_c(P_s - P_\infty)/Bc_p \qquad (14)$$

where

e = evaporation rate, lbs. per hour
A = area of evaporation, sq.ft.
f_c = external heat-transfer coefficient, B.t.u. per hour ft.^{2} °F.
P_s = saturated vapor pressure at airfoil surface, in. Hg
P = saturated vapor pressure of ambient air, in. Hg
B = barometric pressure, in. Hg
c_p = specific heat of air, B.t.u. per lb. °F.

The vapor pressure difference necessary to evaporate all of the impinging moisture is given by $P_s - P_\infty$. Fig. 14 compares the surface temperatures required for complete evaporation over a range of ambient temperatures with the temperatures resulting from the dry-air analysis.

For the all-aluminum type of blade construction employed in the H-5 helicopter, in which excellent chordwise heat conductance is obtained, the most efficient anti-icing system will not evaporate all the impinging moisture but will evaporate only a portion and maintain trailing-edge temperatures just sufficiently high to prevent freezing of the liquid runback.

Part IV

The H-5 ice control installation consisted of the following: (a) a source of heated air; (b) ducting from the source of heated air to the rotary collector at the rotor hub; (c) a rotary collector to transfer the heated air to the rotating blades; (d) controls for varying the heat supplied; (e) a fan for varying the flow rate of heated air; (f) a metering tube and orifice for measuring airflow; and (g) pressure and temperature indicating and recording equipment.

Assessment of the relative merits of exhaust heat exchangers and independent combustion heaters was made before choosing a source of heated air. An independent combustion heater was chosen since it provided greater flexibility for test purposes, was much cheaper, was more readily available, and had characteristics that were known with a greater degree of certainty than those of a specially designed heat exchanger. The preliminary calculations indicated that the heat requirements were approximately 125,000 B.t.u. per hour with an airflow rate of approximately 1,700 lbs. per hour. The capacities chosen for the test equipment were 200,000 B.t.u. per hour and 2,000 lbs. per hour with a temperature rise of approximately 200°F. above ambient to be made available at the blade duct entry. Means were provided for varying the heat flow from 90,000 to 180,000 B.t.u. per hour. To relieve the pilot of excessive manipulation of heater controls, an automatic fuel-air regulator was incorporated in the system.

FIG. 10
f_c vs DISTANCE FROM STAGNATION POINT

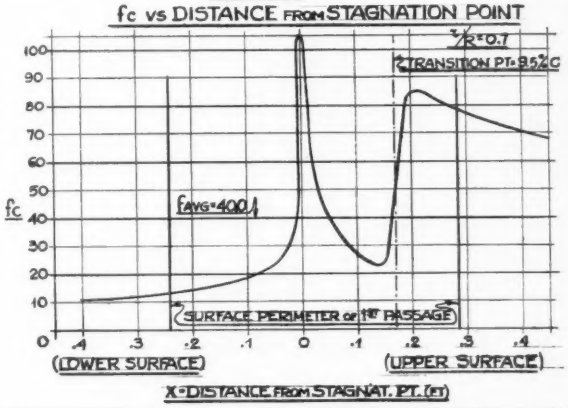


FIG. 11
f_c vs DISTANCE FROM STAGNATION PT.

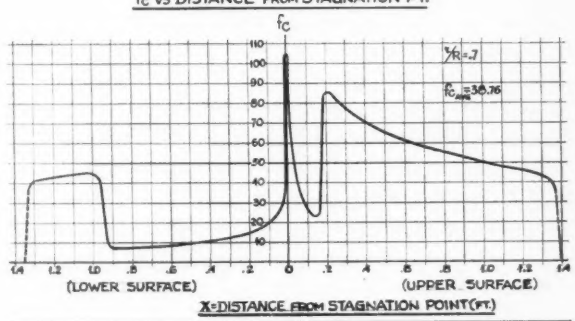
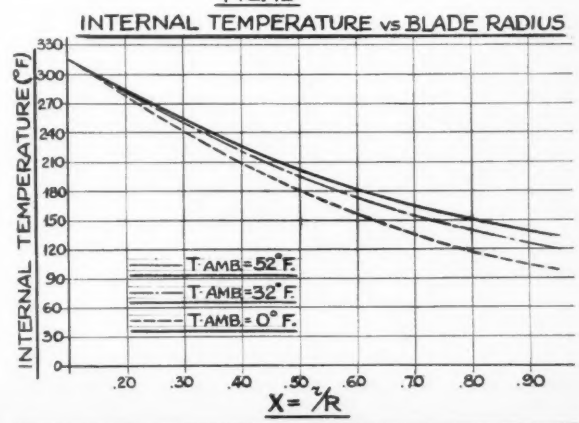


FIG. 12
INTERNAL TEMPERATURE vs BLADE RADIUS



The system is illustrated in the photographs on pages 25 and 26.

The complete heater installation, together with combustion and heated air fans, was constructed as a single bench assembly and bolted externally to the left-hand side of the cabin. Thus, the installation was completely accessible for adjustment and could be quickly removed for modifications in the shop. An actual installation would, of course, be internal.

The duct from the heater to the rotary collector was a conventional wire and fabric duct with asbestos and fiberglas lagging. Like the heater, it was completely external for reasons of convenience. Considerably less weight of lagging would obviously be required in an internal installation.

The rotary collector was in the form of a ring of rectangular cross section supported on the swashplate assembly. The lower, stationary component of the collector was supported on the nonrotating portion of the swashplate assembly and formed three sides of the rectangular cross section. It was spun from a single sheet of aluminum alloy. The upper, rotating component of the collector was supported on the rotary portion of the swashplate assembly and formed the upper side of the rectangular section, being simply a heavy plate of aluminum alloy. Mounted on the upper face of the stationary component of the collector were circular segments of graphite at the inner and outer diameters of the collector, matching the polished lower face of the rotary component and thus forming a seal at the inner and outer diameters. The rotary plate was forced down upon the graphite seal by means of springs, at a contact pressure of $\frac{1}{2}$ lb. per sq.in. Three flanged holes in the rotary plate provided attachment for the flexible ducts to each of the three blades. The complete assembly was thoroughly lagged with asbestos sheet.

Temperature measurements were made on the blade surface spanwise and chordwise and in the blade duct at root and tip by means of thermocouples, and these temperatures were recorded on automatic recording equipment installed in the baggage compartment. Current was transmitted through the rotor hub by means of slip rings installed in the swashplate assembly.

During flight and ground tests the flow of heated air was the primary variable, and a rheostat was employed to control the speed of the heated air fan. The heated air exit temperature was held at a substantially constant value, the fuel-air ratio being automatically maintained approximately constant by a diaphragm-type regulator located in the fuel supply line. The combustion airflow rate was manually controlled in similar fashion to the heated airflow rate.

Operating procedure was to observe and record data at one set of flow conditions. Different sets of conditions were obtained by changing the heated air fan speed, thus changing the flow of air through the heater. Since it is then necessary to burn a different quantity of fuel to keep the heater exit air temperature constant, the operator then readjusted the combustion air fan speed while observing the exit air temperature. He was relieved of the necessity of readjusting the fuel flow rate by the automatic fuel-air regulator. Approximately 10 flight-hours were accumulated during the test.

FIG. 13

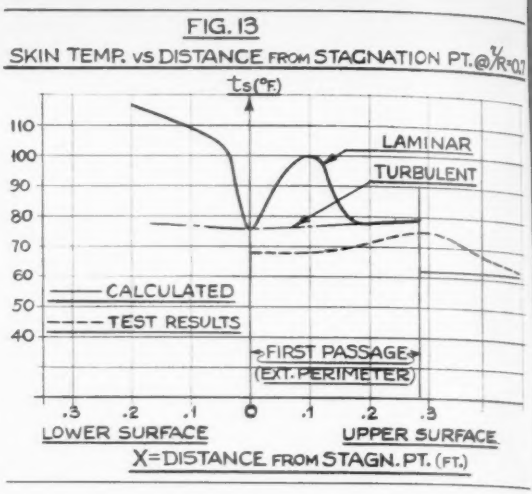
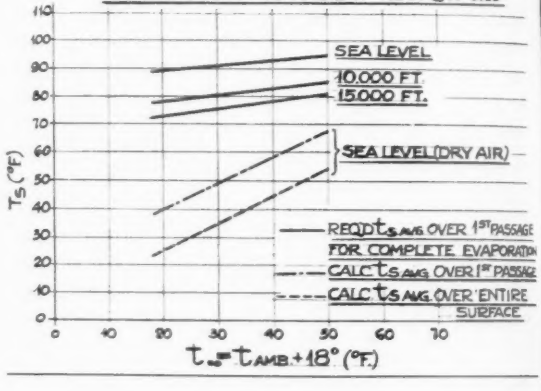


FIG. 14



Part V

It has already been observed that good agreement was reached between predicted dry-air performance and flight-test results. Flight or ground tests under controlled icing conditions are clearly indicated as the immediate course of further investigation. Despite the unavoidable limitations to the scope of the program, the primary objective has been, in large part, attained in that a practical basis for a service-worthy ice-control installation has been achieved.

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Control-Surface Position Feedback in Flight-Control Systems

(*Continued from page 19*)

$F_3(p) = (Aq^2 + BUqp)/(CUp^3 + Dqp^2 + EUqp)$

where the effect of variations in the forward velocity on $F_3(p)$ has been neglected; A, B, C, D, and E are constants for subsonic speeds; U is the forward velocity; and q is the dynamic pressure.

$F_2(p)$ may be written as

$$F_2(p) = G(p)/(Jp^2 + cp + k)$$

with $k = Fq$ where F is a constant. Eq. (4) then gives

$$\frac{\theta_0}{\theta_i} = \frac{G(p)(Aq^2 + BUqp)}{(CUp^3 + Dqp^2 + EUqp)(Jp^2 + cp + Fq) + F_1(p)G(p)(Aq^2 + BUqp) + \beta G(p)(CUp^3 + Dqp^2 + EUqp)}$$

Now if $\beta = 0$, it turns out that although the transfer function, θ_0/θ_i, theoretically contains q and U as a parameter, the constants of the usual conventional airplane are so related that θ_0/θ_i often shows little dependency on q or U for the frequencies of interest.

In other words, a linear autopilot with little or no feedback, once it is adjusted for optimum response at a given air speed and altitude, tends to give satisfactory response for any normal flight condition.

When a large amount of surface feedback is used, it develops that θ_0/θ_i is a strongly varying function of q, and an optimum adjustment obtained at one flight condition may give an unsatisfactory response at another flight condition. The alleviation of this condition is clearly indicated. It is necessary to make one or several of the parameters, such as β or $F_1(p)$, vary in some appropriate manner with q and/or U.

Conclusions

The value of constant negative control-surface position feedback lies generally in the reduction of phase lags in, and the linearization of, that part of a flight-control system which involves the servo actuator and control surface and associated circuits. The destabilizing effect of variable or negative surface spring constants, which are sometimes encountered, is also minimized. On the other hand, the introduction of surface feedback brings with it certain possible disadvantages, as discussed above, and a final decision on its use can be made only after careful examination of the particular application. Experience shows, however, that modern day aircraft, especially those with boost or powered control systems, generally require control-surface feedback for adequate stabilization, primarily because of the time lags and nonlinear characteristics found in these systems.

Reference

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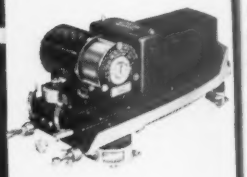

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I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

Please do not order Preprints of these papers at this time.
See page 124 for Preprints that are immediately available.

Shear Center for Thin-Walled Open Sections Beyond the Elastic Limit

By

G. H. Handelman
Carnegie Institute of Technology

The location of the shear center of a thin-walled open section stressed beyond the elastic limit is determined by methods similar to those used in the elastic case. Through an analysis of the stress and strain components, the problem is reduced to determining one constant in the case of symmetric sections. This can be found from the magnitude of the applied force. The location of the shear center can then be found. Calculations for channel sections are carried out in detail, and the influence of the load and stress-strain law is shown in a numerical example. Formulas are also given for nonsymmetrical sections. The shear center, in the nonelastic case, is not a property of the section alone but depends on the stress-strain law and the applied force.

On the Stability of Two-Dimensional Laminar Jet Flow of Gas

By

S. I. Pai
University of Maryland

The stability of two-dimensional laminar jet-type flow of both an incompressible fluid and a compressible fluid has been investigated by the method of small perturbations. Both the symmetrical and the antisymmetrical disturbances are investigated separately.

In the case of incompressible fluid, the solutions of neutral stable disturbances in an inviscid fluid are obtained first. Then the case of viscous fluid is analyzed. Both the symmetrical and the antisymmetrical disturbances are unstable for large Reynolds Numbers, but the region of instability of symmetrical disturbances lies inside that of the antisymmetrical ones. The general shape of the neutral stable wave number against Reynolds Number curve of the jet-type flow is different from that of the velocity profile of ordinary boundary-layer flow or Poiseuille flow. First, the effect of viscosity on the neutral stable disturbance in inviscid fluid is always stabilizing for jet-type flow. Second, when the wave number tends to zero and the Reynolds Number is large, the jet-type flow is always unstable. Hence, for the upper branch of the neutral stable wave number against Reynolds number curve, wave number increases with Reynolds Number, and there is no lower branch of this neutral stable curve for the jet-type flow.

In the case of compressible fluid, the asymptotic behavior of the solutions at infinity is discussed. The stability of a two-dimensional jet of inviscid fluid is analyzed, and the cases of viscous fluid are indicated. There is some similarity in the solutions of the case of compressible fluid and of the case of incompressible fluid.

So far as laminar stability is concerned, an important difference exists between the case of supersonic and subsonic disturbances relative to the velocity of the surrounding stream of the jet. The amplitude of the subsonic disturbance dies out rapidly with the distance from the axis of the jet. The neutral supersonic disturbances are actually progressive sound waves whose wave length and phase velocity are completely arbitrary and which have no significance for stability of the jet flow.

When the Mach Number of the maximum velocity of the jet relative to the velocity of the surrounding stream is high enough, the jet-type flow tends to be stable with respect to small disturbances.

Preprint No. 310

Effect of Turbulence Level of Incident Air Stream on Local Heat Transfer and Skin Friction on a Cylinder

By

W. H. Giedt
University of California at Berkeley

At the conclusion of a previous investigation of local heat-transfer and local pressure coefficients around a cylinder the need for simultaneous local skin-friction coefficient measurements was indicated. In addition, the results of the skin-friction measurements of Fage and Falkner suggested that the influence of the turbulence level in the free air stream on the local heat transfer should be investigated. Data were therefore taken and are presented for the local heat-transfer coefficient, pressure coefficient, and skin-friction coefficient on a cylinder below and in the critical range of Reynolds Number. The effect of artificially increased turbulence in the free air stream on these local quantities was also determined. Data for these quantities, taken under identical flow conditions and on models of the same geometry, have not been available previously. The results are partly explicable in terms of available theory and experience and in part present new effects requiring further consideration.

Some Results of Sweptback Wing Structural Studies

By

A. L. Lang and R. L. Bisplinghoff
Massachusetts Institute of Technology

Static stress and deflection tests have been conducted in the laboratory on a 45° sweptback single-cell beam. The results of these tests are compared with simplified theories for predicting stresses and deformations in swept-shell beams. The agreement between theoretically and experimentally determined deflections is closer than the stresses, but both agree within acceptable engineering accuracy. Both cases of skewed ribs and ribs perpendicular to the spars are included. Since some degree of root-support deformation is unavoidable in sweptback wing static tests, a method is described of accounting for this effect in the theory.

Preprint No. 330

NECROLOGY

(*Continued from page 7*)

in the Test Pilot Training Division, Naval Air Test Center, Patuxent River, Md. After his graduation, he was stationed at the Marine Corps Aviation Technical School, Marine Corps Air Station, Quantico, Va., as an Instructor of Aerodynamics, Weight, and Balance.

During his years in the Marine Corps, Captain Roy was awarded the Distinguished Flying Cross, Naval Unit Citation, Presidential Unit Citation, and Asiatic Pacific Ribbon with three stars.

Harry A. Sutton

Harry Allen Sutton, I.A.S. Fellow and Founder Member, died suddenly last spring in Washington, D.C. He was 56 years old.

Mr. Sutton was one of the first persons to enter the Aviation Section of the U.S. Army Signal Corps after the declaration of war by the United States in April, 1917. An Air Corps pilot and commissioned officer, he was assigned first as a Flying Instructor at San Antonio, Tex., and later to the Airplane Branch of the Experimental Engineering Section at McCook Field, Dayton, Ohio.

In 1928, Mr. Sutton conducted what was then a "dangerous and difficult" series of flight tests to determine the spinning characteristics of several types of observation and pursuit planes. His records of these characteristics were considered as excellent examples of precise engineering data. In recognition of his accomplishments for "the most meritorious flight by a pilot of the Army Air Corps," he was awarded the Mackay Trophy for 1928. He was discharged from the service in 1929, but he remained active in the Air Corps Reserve.

Mr. Sutton's first position was with American Airways, Inc., the operating company of the Aviation Corporation, as Chief Engineer and Vice-President. (American Airways is now American Airlines System.) He was responsible at that time for initiating many of the operating and maintenance practices that are now standard for all commercial air lines. In the early 1930's, he left American to join the Aerodynamics Group of Curtiss Aeroplane and Motor Company as Chief Test Pilot and Group Head. Some years later, he became associated with Consolidated Airplane Company and remained on as Director of Engineering when Consolidated merged with Vultee Aircraft, Inc., in March, 1943, to form Consolidated Vultee Aircraft Corporation. Not long before his death, he had severed his connection with Ryan Aeronautical Company where he had been Director of Engineering since about 1946.

Mr. Sutton was graduated in 1916 from the Oregon Agricultural College with a B.S. degree in Mining Engineering. Subsequently, he studied aeronautical engineering at the U.S. Army Air Corps' Aeronautical Engineering School and at Massachusetts Institute of Technology.

In 1948, Mr. Sutton was named to the Chairmanship of the panel on the Committee for Guided Missiles of the Research and Development Board, as well as a Consultant to this same Committee.

News of Members

▸ **Kenneth P. Bowen** (M.), Vice-President in Charge of Manufacturing, Northrop Aircraft, Inc., has been elected Chairman, Manufacturing Methods Committee, Western Region, Aircraft Industries Association.

▸ **William P. Lear** (A.F.), Chairman of the Board and Director, Research and Development, Lear, Incorporated, was awarded a Doctor of Engineering degree by the University of Michigan. This degree was presented to him "in recognition of his tremendous contribution to aviation communication and aircraft stabilization research and development."

▸ **Commander Raymond D. MacCart,** U.S.N. (Ret.) (F.), President of Brown Brothers Foundry, Inc., President of Manufacturers Acceptance Company, and Manufacturing Manager for Petroleum Heat and Power Company, has been elected Chairman of the Stamford-Greenwich Manufacturers Council, Stamford, Conn.

▸ **Dr. Glenn Murphy** (M.), Professor, Theoretical and Applied Mechanics, Iowa State College, was the recipient of the 1951 George Westinghouse Award presented by the American Society for Engineering Education. Presentation took place at the A.S.E.E. Annual Dinner on June 28.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of I.A.S. members. All members are, therefore, urged to notify the New Editor of changes as soon as they occur.

Conbert Hans Benneck (T.M.), assigned by Sperry Gyroscope Company to 339th Fighter Squadron, A.P.O. 994, c/o Postmaster, San Francisco, Calif.

Harold S. Bentley (T.M.), Designer Junior, Goodyear Aircraft Corporation, The Goodyear Tire & Rubber Company. Formerly, Sales, Bender-Rieger, Inc.

Richard Boyles, Jr. (T.M.), Draftsman "A," Preliminary Design Department, Lockheed Aircraft Corporation. Formerly, Junior Engineer, NEPA Division, Fairchild Engine and Airplane Corporation.

Charles Buhman, Jr. (T.M.), Design Engineer, Lockheed Aircraft Corporation, Marietta, Ga. Formerly, with McDonnell Aircraft Corporation.

Frank Carlson (T.M.), Engineering Draftsman, Transmission Group, Bell Aircraft Corporation. Formerly, Junior Engineer, Bell Aircraft.

John R. Churchill (T.M.), Research "E," Missile Development, North American Aviation, Inc. Formerly, Stress Analyst, NEPA Division, Fairchild Engine and Airplane Corporation.

Thomas C. Connor (T.M.), now Research Engineer, Continental Aviation and Engineering Corporation

Second Lieutenant Richard K. Coulter, U.S.A.F. (T.M.), now Training as Specialist 1037, Air Force Bombardment School, Mather Air Force Base, Calif.

First Lieutenant Charles N. Crawford (T.M.), 167th Ftr. Bmr. Sq., Godman Air Force Base, Ky. Formerly, Aerodynamicist, North American Aviation, Inc.

Brigadier General F. Trubee Davison (M.), now Director of Personnel, Central Intelligence Agency.

Major William S. Dawson (A.M.), Chief, Plans Division, Headquarters, 1808th Airways and Air Communications Service Wing, U.S.A.F., Tokyo, Japan. Formerly, Commanding Officer, 1951st Airways and Air Communications Service Squadron.

Paul D. Daymude (T.M.), now Instrument Tester and Inspector, Instrument Test and Final Inspection, Bendix Aviation Corporation.

E. H. Dowell (M.), Manufacturing Engineer, Industrial Engineering Department, Apparatus Division, Canadian Westinghouse Company. Formerly, Aeronautical Engineer, de Havilland Aircraft of Canada, Ltd.

Harry J. Dunlop (T.M.), now Civil Engineer, U.S. Bureau of Reclamation, Placerville Field Station, Placerville, Calif.

Fulton E. Dye, Jr. (T.M.), Aerodynamics Research Department, Cornell Aeronautical Laboratory, Inc. Formerly, Student.

Naval Cadet Harold E. Emmick, U.S.N. (T.M.), Flight Training, Naval Auxiliary Air Station, Whiting Field, Milton, Fla. Formerly, Pre-Flight Training, Naval Air Station, Pensacola, Fla.

Robert H. Essig (M), Aeronautical Research Scientist, Lewis Flight Propulsion Laboratory, N.A.C.A. Formerly, Re-

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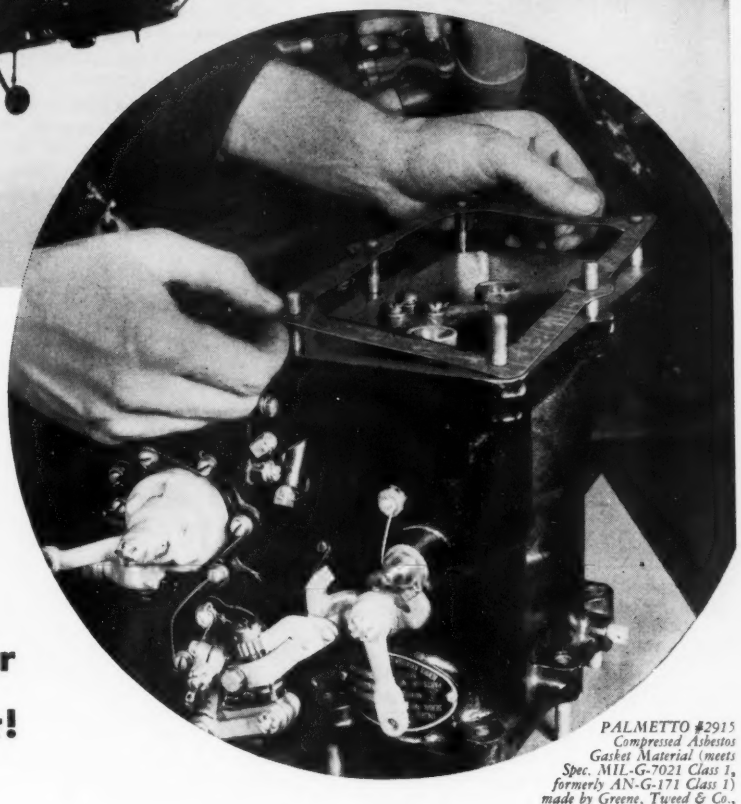

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WICHITA COUNCIL PRESIDENT

George W. Baughman (M.), B-47 Engineering Representative, Wichita (Kan.) Office, Georgia Division, Lockheed Aircraft Corporation, has been elected President of the Wichita Council of Technical Societies. The Council consists of twelve technical societies representing 930 members located principally in the city of Wichita. Mr. Baughman, prior to assuming his present position with Lockheed last spring, had been with Cessna Aircraft Company for 10½ years in various engineering project capacities.

search Associate, Mechanical Engineering Department, Ohio State University.

First Lieutenant Ole Peter Flaa, U.S.A.F. (T.M.), Fighter Pilot and Project Engineer, Power Plant Laboratory, Wright-Patterson Air Force Base, Ohio. Formerly, Experimental Engineer, International Harvester Company.

Colonel Richard Gimbel, U.S.A.F. (A.M.), Professor of Air Science and Tactics, Yale University. Formerly, Comptroller, 10th Air Force, Selfridge Air Force Base, Mich.

Martin Goland (M.), Associate Director for Engineering, Midwest Research Institute. Formerly, Chairman, Engineering Mechanical Division, Midwest Research Institute.

S. A. Gordon (T.M.), now Consulting Aeronautical Engineer, Battelle Memorial Institute, Columbus, Ohio.

Harold Gorowitz (T.M.), Aerodynamicist "C," North American Aviation, Inc. Formerly, Aeronautical Engineer, Ames Aeronautical Laboratory, N.A.C.A.

Stanley C. Hellman (T.M.), Assistant General Manager, Columbus Division, North American Aviation, Inc. Formerly, Manager, Dayton (Ohio) Office, North American.

Private Thomas G. Horeff (T.M.), 9330 T.S.U.-O.G.M.C., Redstone Arsenal, Huntsville, Ala. Formerly, Flight Test Data Analyst, McDonnell Aircraft Corporation.

John J. Hospers (A.F.), Assistant to the General Manager, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Sales Manager, Chance Vought.

Commander H. J. Huester, U.S.N.R. (M.), Aviation Supply Office (T.D.O.), 700 Robbins Ave., Philadelphia. Formerly, Aeronautical Standards Group, Departments of the Navy and the Air Force, Pentagon Building, Washington, D.C.

Cass F. Hurc (M), Project Engineer, Research Department, The Parker Pen Company. Formerly, Head, Engineering Drawing Department, The Aeronautical University, Inc.

Ted T. Iida (T.M.), now Draftsman "A," Lockheed Aircraft Corporation.

Joseph J. Jerger (A.F.), Manager, Aero-Mechanics Section, Missile and Radar Division, Raytheon Manufacturing Company. Formerly, Consulting Engineer, Guided Missiles Division, Fairchild Engine and Airplane Corporation.

Chester I. Keasling (M.), Division Manager, General Overhaul and Maintenance Division for Commercial Aircraft, Pacific Airmotive Corporation.

James F. Kelleher (T.M.), Analytical Engineer "A," Dynamic Analysis Group, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Junior Aeronautical Engineer, Personal Aircraft Research Center, Agricultural and Mechanical College of Texas.

Commander N. E. Knapp, U.S.N. (M.), Guided Missile Division, Bureau of Aeronautics, Department of the Navy. Formerly, Lieutenant Commander, Production Officer, Overhaul and Repair Department, Naval Air Station, Norfolk, Va.

REJOINS GENERAL ELECTRIC

David Roy Shoults (A.F.) has assumed the duties of Director, Aircraft Nuclear Propulsion Project for the Air Force and Atomic Energy Commission, General Electric Company, Lockland, Ohio. He was previously associated with G-E from 1925 to 1945. During the last 6 years, he has served as Vice-President for Engineering, Bell Aircraft Corporation; Vice-President for Engineering, The Glenn L. Martin Company; and, most recently, Director of Engineering, Avo, Inc. The first American civilian to inspect Britain's then top-secret Whittle jet engine in an official capacity, Mr. Shoults was one of those who in 1941 was ordered by the late Gen. H. H. Arnold to make recommendations for the possible American use of the Whittle engine.

WINS AIRPOWER AWARD

Michael Stroukoff (A.F.), Founder and Chief Engineer, Chase Aircraft Company, Inc., was awarded the 1951 Airpower Trophy by the New Jersey Wing of the Air Force Association. The award was made to Mr. Stroukoff for designing the C-123 troop and cargo-carrying transport for the U.S. Air Force, believed to be the first aircraft in aviation history to have performed successfully as a glider, with piston engines, and with jet power.

Edith Hall Lively (T.M.), Materials Requirements, Marietta (Ga.) Division, Lockheed Aircraft Corporation. Formerly, Graduate Student.

Lee Roy Malmsten (M.), now Technical Advisor, J & J Aircraft, Inc.

William J. McCurdy (T.M.), Graduate Student in Aeronautical Engineering, Massachusetts Institute of Technology. Formerly, Aeronautical Research Engineer, Research Department, United Aircraft Corporation.

Kenneth T. McQueen (T.M.), now Aeronautical Engineer GS-9, Edwards Air Force Base, Muroc, Calif.

H. Thayer Murphy (M.), Aeronautical Engineer, Bureau of Aeronautics Representative, U.S. Navy, Dallas, Tex. Formerly, Mechanical Engineer, Lewis Flight Propulsion Laboratory, N.A.C.A.

Robert J. Naegele, II (T.M.), Junior Engineer, Marquardt Aircraft Company. Formerly, Aerodynamicist, Lockheed Aircraft Corporation.

Daniel M. Parobek (T.M.), now Engineer, Lewis Flight Propulsion Laboratory, N.A.C.A.

Captain Russell S. Paulnock, U.S.A.F. (T.M.), Graduate Student in Aeronautical Engineering, Massachusetts Institute of Technology. Formerly, Lieutenant, 5039th Base Flight Squadron, 5039th Air Transport Group, Elmendorf Air Force Base, Alaska.

Guenther H. Pomer (T.M.), Head, Power Plant Engineering Group, Overhaul and Repair Department, Naval Air Station, Jacksonville, Fla. Formerly, Assistant Engineer, Jet Engine Fuel-Controls, Bendix Aviation Corporation.

H. Allen Price (A.F.), Manager, Aircraft Division, Parsons Corporation. For-

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merly, Contracts Administrator, Stanley Aviation Corporation.

Michael K. Rastiello (T.M.), Designer, Piasecki Helicopter Corporation. Formerly, Designer, Lockheed Aircraft Corporation.

Irvine E. Ross, Jr. (M.), Division Engineer, DC and Specialty Motor Engineering Division, Fractional Horsepower Motor Engineering Divisions, General Electric Company, Ft. Wayne, Ind. Formerly, Assistant Divisions Engineer, G-E.

E. W. Saboya de Albuquerque (T.M.), Research Division, Ministry of Aeronautics, Rio de Janeiro, Brazil. Formerly, Director of Purchases of Codiq S.A., São Paulo, Brazil.

Virgil A. Sandborn (T.M.), now Research Assistant, Lewis Flight Propulsion Laboratory, N.A.C.A.

Colonel Philip Shepley, U.S.A.F. (M.), Executive Officer, Air Force Section, Military Assistance Advisory Group, France (A.P.O. 58, c/o Postmaster, New York).

James Hopkins Smith, Jr. (A.M.), now Special Assistant to the Secretary of the Navy, Department of the Navy, Washington, D.C.

William W. Treasure (T.M.), Engineer, Propulsion Group, Helicopter Division, McDonnell Aircraft Corporation. Formerly, Experimental Test Engineer, Pratt & Whitney Aircraft Division, United Aircraft Corporation.

Ernest J. Tursich (T.M.), Aeronautical Engineer, Goodyear Aircraft Corporation, The Goodyear Tire & Rubber Company. Formerly, Instructor of Engineering, Division of Engineering, Iowa State College.

Walter Tydon (M.), Chief Engineer, Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation. Formerly, Chief of Design Engineering, Fairchild Aircraft Division, Fairchild.

Robert F. White (T.M.), Engineer, Aerodynamics Department, Grumman Aircraft Engineering Corporation. Formerly, Student.

Lieutenant Colonel Alfred L. Wolf (A.M.), Air Judge Advocate, Headquarters, U.S. Air Force Europe, A.P.O. 633, c/o Postmaster, New York.

Eric W. Wood (M.), now Priorities Administrator, Fairchild Engine Division, Fairchild Engine and Airplane Corporation.

Charles M. Zimney (M.), Research Engineer, Jet Propulsion Laboratory, California Institute of Technology. Formerly, Assistant Professor of Aeronautical Engineering, Department of Aeronautical Engineering, University of Minnesota.

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review.*

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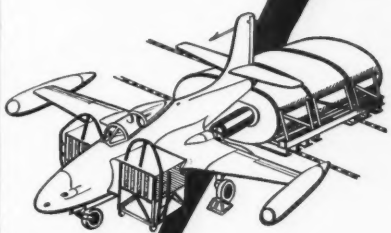

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Corporate Member News

• **Aeroquip Corporation** . . . A new plant in Burbank, Calif., operated by Aeroquip Coupling Corporation, an Aeroquip subsidiary, went into full operation early last June. Aeroquip has also recently completed an addition of a new 65,000-sq.ft. building to the main Jackson, Mich., plant and the acquisition of another subsidiary, Metalco, Inc., with a plant in Cheboygan, Mich. Aeroquip's facilities have thus been increased by over 100,000 sq.ft.

• **AiResearch Manufacturing Company, Division of The Garrett Corporation** . . . A 140-hp. air-turbine starter, said by the company to be the most powerful air starter yet developed, is able to start turbojet and turboprop engines in the 10,000-lb. thrust and the 8,000-hp. class within 10 to 30 sec. This low-pressure pneumatic unit, weighing only 32 lbs., has successfully completed the final cycling tests required by the Air Force . . . The ground floor of the Rexall Drug building at Beverly and LaCienga Blvds., Los Angeles, has been leased for its Purchasing Department.

• **Airquipment Company, Subsidiary of Lockheed Aircraft Corporation** . . . Weber Showcase & Fixture Company has purchased Airquipment for a reported $1,300,000. The Aerol Company, formerly a subsidiary of Airquipment, was not included in the sale, and it has become a direct subsidiary of Lockheed Aircraft.

• **American Steel & Wire Company** . . . A wire rope recommendation book entitled *The Right Rope for The Job* was recently published.

• **Beech Aircraft Corporation** . . . The U.S.A.F. T-36 is going into production at Wichita. The Beech Aircraft design was the winner in a competition for the development of a new-type twin-engine trainer.

• **Bendix Aviation Corporation** . . . An agreement to purchase the South Montrose Manufacturing Company, South Montrose, Pa., has been concluded. This purchase represents an additional 102,000 sq.ft. of floor space and will form a new division to be known as the Montrose Division of Bendix Aviation.

• **Bendix Radio Communications Division, Bendix Aviation Corporation** . . . A new illustrated brochure, *This is Bendix*, describes the research, engineering, and production facilities. It is available on request by contacting Bendix Radio's Public Relations Department.

• **Boeing Airplane Company** . . . Sheet aluminum designed for Boeing planes is being protected by a coating of a plastic lacquer that can be peeled off like tape. This lacquer is produced by the Minnesota Mining and Manufacturing Company . . . Four departments have been moved from Plant 2, Seattle, to the Renton plant in order to provide more space for work on the B-52 multijet heavy bomber. The departments affected by this move are the B-50 Superfortress fuselage structures, B-50 and C-97 Stratofreighter wing structures, major subassembly and machine assembly, and minor subassembly . . . Before being assigned to specific jobs, newly employed engineers are now undergoing a 3-week familiarization course dealing exclusively with company engineering practices. Hitherto, engineers joining Boeing were given a general indoctrination course conducted by the personnel division for all new factory and office employees.

• **Canadair, Ltd.** . . . Under the terms of a licensing agreement between the Canadian government and Lockheed Aircraft Corporation, Canadair is scheduled to build between 400 and 500 of the Lockheed T-33 trainer for the Royal Canadian Air Force.

• **Consolidated Vultee Aircraft Corporation** . . . The U.S. Air Force took delivery last June on the B-36F, the new and more powerful model of the long-range B-36 bomber. The "F" model is powered by six Pratt & Whitney 3,800-hp. piston engines and four jet engines . . . Kitchen-equipped B-36's are coming off the Fort Worth assembly line. The kitchen has two electric burners, a B-4 oven, an icebox, and storage and working space. An insulated conveyor carries the freshly prepared hot meals forward through an 85-ft. communications tunnel.

• **Cornell University** . . . Members of the staff of The Daniel and Florence Guggenheim Aviation Safety Center at Cornell University have published and authorized several reports on the general subject of aviation safety. These reports include the following: "Aviation Progress and Safety Should March Hand-in-Hand," by Jerome Lederer; "Safety Survey of Pacific Coast Aviation Industry," by William L. Lewis; "Comparative Significance of Transport Safety Statistics," by Rudolph Modley; and "Recent Developments in the Field of Landing Speed Reduction and Hovering Aircraft," by David H. Kaplan.

• **Douglas Aircraft Company, Inc.** . . . The Navy sonic research plane, the Douglas D-558-2 Skyrocket, attained the highest speed and altitude yet recorded in a piloted aircraft on July 3 (see cover picture). This rocket-powered ship, one of three designed and built at the El Segundo Plant, was carried aloft by a B-29 mother plane and launched at approximately 35,000 ft. Bill Bridgeman, Douglas Test Pilot, was at the controls. This flight was a continuation of a program of high-speed investigation initiated by the U.S. Navy and Douglas in cooperation with the N.A.C.A. and similar U.S. Air Force programs.

• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation** . . . C-119 Flying Boxcars will be built at the Government-owned building on the northwest corner of O'Hare National Airport, Chicago. This plant was turned over to Fairchild on June 22.

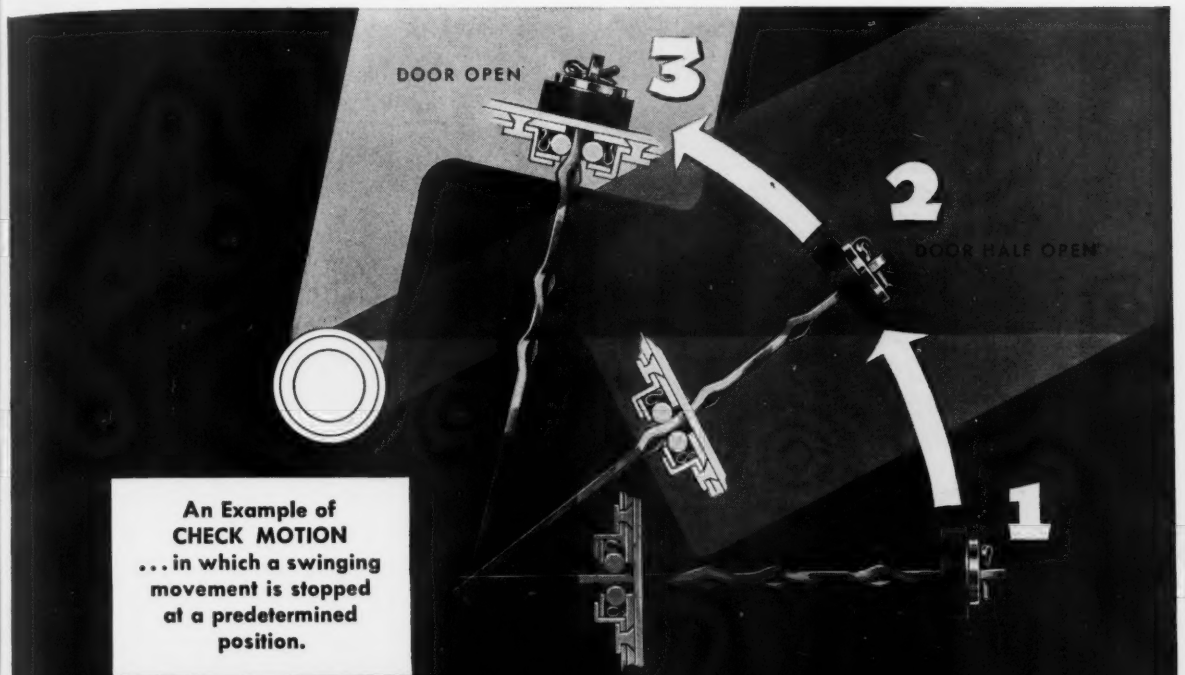
• **Fairchild Engine and Airplane Corporation** . . . A 25-acre tract of land located about 2 miles north of the corporate limits of Hagerstown, Md., has been purchased for use as the site of a new corporation office building . . . Harold K. Pedersen has been named Assistant Treasurer. He was formerly Fairchild's Chief Auditor.

• **The Firestone Tire & Rubber Company of California** . . . The Fuel Cell Division, which has been in operation continually since the beginning of World War II, is producing both self-sealing and nonself-sealing fuel cells for various production airplanes manufactured west of the Mississippi River.

• **General Electric Company** . . . A method of joining silicone rubber to steel with a bonding agent stronger than the rubber itself has been developed. This new primer is said to form strong bonds between silicone rubber and almost any material, including glass, ceramics, and aluminum . . . As part of its expansion program for jet-engine production, the manufacturing of drop forge dies was expected to have been begun in mid-July at the newly leased factory building at Ludlow, Vt. This plant, containing about 50,000 sq.ft. of manufacturing space, was leased for 5 years from Ludlow Industries, Inc. . . . Robert Paxton, who has been G-E's Vice-President in Charge of Manufacturing Policy since September, 1950, was elected to succeed Hardage L. Andrews as an Executive Vice-President of G-E. Mr. Andrews retired from the company after 41 years of service. Mr. Paxton will continue in his manufacturing policy capacity for a temporary period . . . Chester H. Lang, a Vice-President of G-E since 1941, is now in charge of Public Relations with offices in New York. Mr. Lang was formerly in charge of Apparatus Marketing . . . A new two-color booklet, designated GEA-5552, is now available. It covers G-E Type TLC (cradled), 250-volt, d.c. dynamometers for direct connection testing of internal-combustion engines, electric motors, pumps, blowers, and compressors.

• **The B. F. Goodrich Company** . . . Incorporated into the landing-gear structure of the B-47 bomber is an antiskid brake system. The new magnesium wheel that is used in the landing gear is rated to carry 60,000 lbs., although on a loading test a single wheel has actually supported 325,000 lbs., representing a five-to-one safety margin. The new wheels measure 56 in. by 16 in. The four large tires used on the B-47's dual landing gear are capable of taking 240 lbs. pressure to carry a heavy load . . . A new 53,420-sq.ft. building to serve as headquarters for five sales divisions is under construction at 2940 E. 44th St., Los Angeles. The building is scheduled for occupancy on or about November 1 . . . George Walker Sawin, who has been President of The B. F. Goodrich Rubber Company of Canada, Ltd., since 1941, has resigned for reasons of health. Ira G. Needles, a Vice-President of the company, was elected to serve as the new President.

• **Jack & Heintz, Inc.** . . . Under the terms of a joint A.M.C.-Navy facilities contract, the company is planning to more than double its present output when in full operation late in 1952. In addition to machine tools and other equipment, about two-thirds of which will be supplied from the Air Force and Navy facility pools, the program requires the leasing of the company's former Plant No. 1 in Bedford, Ohio. This 70,000-sq.ft. plant is owned by the Universal Wire Spring Company of Cleveland.



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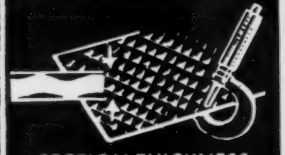

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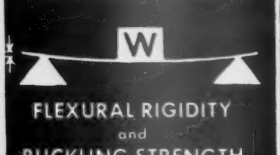

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• **Walter Kidde & Company, Inc.** . . . A new booklet on *How To Prepare Your Plant For Atomic Attack* is available without cost to interested firms. Write to Department A, 675 Main Street, Belleville 9, N.J.

• **Lear, Incorporated** . . . A new quick-disconnect fitting for time-saving short cuts in installation and servicing of accessories is a feature of Lear model 150 Series Power Units and model 568A screw jacks. The fitting eliminates the need for fastening and unfastening the safety wire at the connection of the flexible shafting. Actual field tests are said to have shown a saving of as high as 2 hours, 50 min. in the installation of an 8 screw-jack system because of the ease of connections. The model 150 Series Power Units with the quick-disconnect fittings were designed for use in various actuating systems requiring either 27-volt d.c. or 400-cycle a.c. reversible motors . . . A new booklet, geared to the personal plane field, tells the story of the Lear L-2 Autopilot. Copies of this booklet are available gratis by writing to Norman Warren, Lear, Inc., 11916 West Pico Blvd., Los Angeles . . . At a recent meeting of the Board of Directors, W. D. Espy was elected Vice-President; A. Durham, Assistant Secretary and Assistant Treasurer; and George K. Otis, Assistant Secretary . . . Kenneth MacGrath, Vice-President, Whirlpool Corporation, has been elected to the Board of Directors.

• **Lockheed Aircraft Corporation** . . . One of five companies to enter a design competition for the development of a new turboprop medium cargo plane, Lockheed came out the winner. The first model of this new ship, carrying the design designation L-206, will be powered by four Allison T-38 turboprop engines. This freighter is distinguished by a squat fuselage with a cargo floor only 45 in. from the ground and large aft cargo doors, permitting straight-in loading of bulky cargo without special freight-handling equipment . . . A portable outdoor freight elevator and an in-plane mechanical stevedore to facilitate air-cargo handling were introduced in July. The 10- by 10-ft. elevator can raise 10,000 lbs. more than 12 ft. The "stevedore" is described as a subfloor endless chain running the length of the cabin. Both pieces of equipment are powered by the plane's own electric system. Developed by Lockheed in conjunction with their former subsidiary, Airquipment Company (now Weber Aircraft Company), these companion pieces are said to permit one man to load an entire plane singlehandedly in an emergency . . . A 69,000-sq.ft. building that has been used as a warehouse is being converted for aircraft manufacturing. Production on wing and tail sections of Super-Constellation transports is expected to begin there this month.

• **The Glenn L. Martin Company** . . . The P5M-1 Marlin completed its first flight last June. This new Navy flying boat is powered with two 3,250-hp. Wright Turbo-Compound engines.

• **McDonnell Aircraft Corporation** . . . A sound muffler to control the noise level of the exhaust of the Navy F2H-2 Banshee jet fighter during various ground tests has

Today's speeds demand electronic gunnery

Today, with interceptors capable of closing in at blinding speeds, the problem of effective gunnery for bomber protection becomes increasingly acute. Split-second tracking, computation and firing are demanded — and complex, compact, light-weight electronic instruments furnish the answer. Arma — working closely with our Armed Forces since 1918 — has supplied the outstanding engineering, imaginative design and precision manufacture that play a leading part in producing these miraculous instruments.

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ENGINEERS' NOTEBOOK

New Clamp Allows Attachment of Instruments from Dial Side of Panel

Significant savings in assembly and servicing time are achieved by Marman Products' new instrument mounting clamp. The clamp is installed on the rear of the panel but mounting or removing is easily accomplished from the dial side of the panel by adjusting only one clamp actuator screw. Marman part No. 23906 clamp conforms to specification MIL-C-6818 and is installed in accordance with Specification MIL-C-6822.

Save Cost, Time and Weight with Marman Standard Clamps for Special Applications

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been installed at McDonnell. The muffler was built by Industrial Sound Control, Inc. . . . Helicopter Models 79 and 79A have been undergoing engineering tests of components and evaluations of installations.

• **North American Aviation, Inc.** . . . A new digital differential analyzer, which will become air-borne as part of a "Flying Laboratory," will be used for in-flight testing of guided-missile components. Guidance equipment, such as automatic control and navigation units, can be interconnected with the "brain," which will then do a lot of "heavy thinking" for scientists in rapidly figuring out the proficiency of such equipment in mathematical terms. This information is being sought to support that already obtained with other digital and analog computers in operation in the company laboratories. This "flying" computer was built to North American specifications by Computer Research Corporation . . . The Commonwealth of Australia has been licensed to manufacture the F-86E Sabre jet fighter. Australia is the second allied country licensed to manufacture the Sabre; Canada is the other country. The Australian model will be powered by a jet of British design . . . The four-jet RB-45C Tornado was successfully refueled in flight by a Boeing KB-29P tanker. The transfer of fuel was made in a relatively short time . . . Hangar and manufacturing facilities at the Fresno Air Terminal have been leased for a 5-year period and will be used for work on military aircraft.

• **Northrop Aircraft, Inc.** . . . Plans for a 30 per cent expansion, providing for construction and equipping of approximately 450,000 sq.ft. of additional manufacturing area, were announced recently by the U.S. Air Force and Northrop. Approximately $5,300,000 will be expended jointly for the buildings, machine tools, and equipment under the program . . . A 250,000-sq.ft. building at Anaheim, Calif., is to be constructed for the production of optical range finders for the U.S. Ordnance Corps. Northrop will occupy it under lease from the Marda Corporation. The range finders are to be used in tanks. Temporary quarters have been established in Lawndale, pending completion of the building on or about November 1. Full-scale operation is scheduled for 1952.

• **Republic Aviation Corporation** . . . A fuel-system laboratory has been designed and constructed at Republic at a cost of $100,000. In this new laboratory, the company is conducting extensive research and test work in the field of high-speed jet-fighter fuel systems. The current research program includes the development and refinement of fuel systems for Republic fighter planes . . . The F-84G Thunderjets are rolling off the production line fully equipped for mid-air refueling by tanker planes. The "G" refueling system is designed for use with the Boeing-developed "flying-boom" method of in-flight refueling which, in the case of the F-84G, can be accomplished within $2^1/_2$ min. These latest Thunderjets are equipped with automatic pilots to lower pilot fatigue . . . Four job training centers for pre-employment training in semiskilled and skilled jet building work have been opened in public

Pneumatics— **protection for planes in flight**

Modern pneumatic systems provide power to planes in flight . . . power that is more reliable, more foolproof than ever before.

With the new high-volume Kidde compressor, even a leak in the pneumatic system can often be overcome because of unlimited supply of air. This compressor can deliver from ambient pressure, one cfm of free air compressed to 3,000 psi at 35,000 feet altitude.

Kidde Control Valves control the flow of air from bottle to actuator. Kidde dehydration equipment insures dry air. *Kidde Air Fuses* seal off the supply if an air line breaks or is shot away. *Kidde Air Check Valves* permit the flow of air in only one direction . . . guard against a line break between the compressor and the bottle.

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school facilities located in Freeport, Hempstead, Farmingdale, and Huntington, L.I., N.Y. Training classes are also being conducted at the Academy of Aeronautics (Casey Jones School of Aeronautics) at LaGuardia Field and at their North Amityville (L.I.) training facility . . . R. C. Taylor, Vice-President, American Can Company, has been elected to the Board of Directors.

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• **Stratos Division, Fairchild Engine and Airplane Corporation** . . . The cornerstone for the new $2,000,000 plant at Bay Shore, L.I., N.Y., was laid on July 19. This new plant will be a modern steel and concrete structure and will contain 140,000 sq.ft. of floor space for use in the manufacture of aircraft refrigeration and pressurization units and other aeronautical accessories.

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• **Westinghouse Electric Corporation** . . . What are said to be "the world's largest liquid rheostats" are to be built at the Buffalo (N.Y.) plant. These liquid rheostats, each over 20 ft. high, will be used to regulate the speed of large electric motors at a new wind tunnel at the Arnold Engineering Development Center, Tenn. This is a part of $20,000,000 worth of electrical equipment being built for the new project . . . A Department of Information Services which will perform all functions of public relations, employe relations, and related activities has been formed.

• **Wyman-Gordon Company** . . . Groundbreaking ceremonies marking the first step in the construction of a new multimillion dollar press-forging plant took place on June 26. The huge plant will cover more than 200 acres at North Grafton, Mass., and, when completed, will be used for the manufacture of forged parts for military aircraft.

Meet Your Section Chairmen

Robert H. Wendt

Chicago Section

Robert H. Wendt, having recently completed his second decade in the aeronautical industry, is now embarking upon his third one. He began this facet of his life in 1930 when he accepted a job as an Aircraft Apprentice with the Curtiss Aeroplane and Motor Company, Inc., of Buffalo. With the exception of a year spent in the employ of Consolidated Aircraft Corporation while they were still located in Buffalo, Mr. Wendt remained with Curtiss for about 7 years, during which time he worked in various experimental, developmental, testing, and engineering capacities.

Mr. Wendt formed the Wendt Aircraft Corporation in 1938 and became its President and Chief Engineer. During the 2 years in which he was connected with the corporation, he designed and constructed the Wendt W-1 Falconer and the W-2 Swift. In 1940, he became associated with Taylorcraft Aviation Corporation and for the next 5 years served successively as Project Engineer, Chief Engineer, and finally Vice-President. At Taylorcraft, he supervised the design, manufacture, and test of numerous personal aircraft intended for liaison, ambulance, and crop-dusting work. He was also concerned with a project for the Navy on radar-controlled buzz-bomb gliders, with airfoil designing, and with application of ceramic coatings to exhaust systems.

Not long after joining the Globe Corporation in 1945 as Chief Engineer, Mr. Wendt was elected Vice-President of Engineering for Globe's Aircraft Division. Early this past spring, he was also made General Manager in charge of the Globe plants in Joliet, Ill., Williams Bay, Wis., Oxnard, Calif., and Kingman, Ariz.

Mr. Wendt, who was born in Eden, N.Y., on June 14, 1911, became imbued with the idea of an aeronautical profession back in 1930, because it seemed to offer him the "most interesting profession available." But as he looks back over the years, he is unable to determine what might have been the high points of interest; he is, he says, "too busy each day to remember yesterday's interesting episodes."

Some of his education was accomplished in the evening at the Burgard School and the University of Buffalo, while he was working days at Curtiss Aeroplane and Motor Company. Some time later, he was granted a B.T.E. degree from the Allied Institute of Technology, where he is currently on the Board of Advisors.

During the 1930's and 1940's, Robert Wendt owned and flew personal planes. Nowadays, his hobbies, aside from aviation in general, are photography and speed boats. He and his wife, the former Gertrude McGuire, whom he married in 1938, are the parents of two sons, Robert, aged 11, and Gerald, aged 4.

Floyd J. Sweet, Lt. Col., U.S.A.F.

Dayton Section

An early interest in model building and glider flying automatically drew Lt. Col. Floyd J. Sweet, U.S.A.F., into an aeronautical career. The year 1930 was its formal beginning; that was the year in which he was awarded a Federation Aéronautique Internationale (F.A.I.) "C" Soaring Certificate. Seven years later, he received both his C.A.A. Commercial Glider Certificate and a B.S. degree in Aeronautical Engineering from the University of Michigan. He also holds a C.A.A. Private Pilot's Certificate, which he obtained in 1945, as well as a C.A.A. Glider Pilot Examiner Certificate.

His first job, with the Eclipse Machine Division of Bendix Aviation Corporation as an Engineer specializing in detail design, was followed by his becoming Director of the Elmira (N.Y.) Aviation Ground School where he taught aviation trades. Elmira, incidentally, was

Colonel Sweet's home town; he was born there on June 29, 1914.

Colonel Sweet was called to duty early in 1941 as a reserve officer in the U.S. Army Air Corps. During his first 6 or 7 months in the service, he was Proof Officer at the Ordnance Department's Jefferson Proving Ground. Later that same year, he was transferred to the Air Corps Glider Training Program as Director of Ground and Pilot Training. In 1943, he was attached to the Air Materiel Command in the dual capacities of Glider Project Officer and Test Pilot. The next year, he was made Chief of the Weight Branch of A.M.C.'s Aircraft Laboratory. In 1945, he became Chief of the Glider Branch, Aircraft Laboratory. In 1946, he was appointed Chief of the Aircraft Laboratory's Cargo and Assault Airplane Unit, where he remained for the next 4 years. He took over his present assignment as Assistant to the Chief of the Aircraft Section, Weapons System Division, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, in 1951.

Colonel Sweet has experienced many outstanding events in his lifetime, but let him tell about some of them in his own words. "The most interesting episodes of my career have perhaps been since I have been stationed at Wright Field where I have been the Project Engineer and Glider Test Pilot on the XG-15, XG-18A, and XG-20 military gliders. As a Project Engineer, it has been extremely interesting to work with aircraft manutacturers in the development and improvement of gliders. It was doubly interesting in that I was able to perform most of the initial flight testing on these aircraft. A high light of this period was in 1949 when Gen. H. S. Vandenberg presented me with the Evans Trophy, an annual award for the greatest contribution by a glider pilot to the U.S. Air Force Glider Program. The greatest thrill in this field came during a flight testing of the XG-20, which was a 32,000-lb. gross-weight glider of all-metal construction. The most satisfaction was derived from my participation in the development of assault airplanes, the YC-122 and XC-123. Two early events are of interest, that of qualifying as a soaring pilot in 1930 at the age of 16 (I soloed my first airplane 11 years later) and of participating in my first National Soaring Contest a year later. (I have missed competing only twice since and have never missed attending a National Soaring Contest.)"

Colonel Sweet is Director of the Soaring Society of America and Chairman of the Soaring Society of Dayton, as well as a member of the National Sojourners and of Theta Xi fraternity. Aside from his long-standing love of soaring, he enjoys bowling, tennis, and swimming.

FOR DEFENSE

Bell Aircraft Corporation, long recognized for its scientific and productive contributions to the nation's security, is applying all its energies to one of the most diversified and long range programs in the aircraft industry . . . a program which serves all branches of the Armed Forces.

With an imposing list of "aviation firsts" in its history and challenged by the increasing complexities of today's aeronautics, Bell continues in the forefront of many activities. This pioneering company is actively engaged in the development and manufacture of five types of helicopters . . . guided missiles . . . radio controlled bombs . . . specialized research aircraft such as the X-1, the X-2 and the X-5 . . . electronic equipment . . . rocket motors . . . convertiplanes . . . and components for the B-36 and B-47 bombers.

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school facilities located in Freeport, Hempstead, Farmingdale, and Huntington, L.I., N.Y. Training classes are also being conducted at the Academy of Aeronautics (Casey Jones School of Aeronautics) at LaGuardia Field and at their North Amityville (L.I.) training facility . . . R. C. Taylor, Vice-President, American Can Company, has been elected to the Board of Directors.

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• **Thompson Products, Inc.** . . . Flash welding of Douglas DC-6 engine mounts is being carried out at the Bell, Calif., plant.

• **Tinnerman Products, Inc.** . . . A new booklet entitled *Tinnerman Speed Nuts, a Story of Quality* tells how coordination with industry and Government is maintained. It also shows how Tinnerman has stepped up its facilities since World War II to maintain more rigid quality control over its output. This 24-page illustrated booklet may be obtained by writing to Tinnerman's Department 14, Box 6688, Cleveland 1.

• **Westinghouse Electric Corporation** . . . What are said to be "the world's largest liquid rheostats" are to be built at the Buffalo (N.Y.) plant. These liquid rheostats, each over 20 ft. high, will be used to regulate the speed of large electric motors at a new wind tunnel at the Arnold Engineering Development Center, Tenn. This is a part of $20,000,000 worth of electrical equipment being built for the new project . . . A Department of Information Services which will perform all functions of public relations, employe relations, and related activities has been formed.

• **Wyman-Gordon Company** . . . Groundbreaking ceremonies marking the first step in the construction of a new multimillion dollar press-forging plant took place on June 26. The huge plant will cover more than 200 acres at North Grafton, Mass., and, when completed, will be used for the manufacture of forged parts for military aircraft.

Meet Your Section Chairmen

Robert H. Wendt

Chicago Section

Robert H. Wendt, having recently completed his second decade in the aeronautical industry, is now embarking upon his third one. He began this facet of his life in 1930 when he accepted a job as an Aircraft Apprentice with the Curtiss Aeroplane and Motor Company, Inc., of Buffalo. With the exception of a year spent in the employ of Consolidated Aircraft Corporation while they were still located in Buffalo, Mr. Wendt remained with Curtiss for about 7 years, during which time he worked in various experimental, developmental, testing, and engineering capacities.

Mr. Wendt formed the Wendt Aircraft Corporation in 1938 and became its President and Chief Engineer. During the 2 years in which he was connected with the corporation, he designed and constructed the Wendt W-1 Falconer and the W-2 Swift. In 1940, he became associated with Taylorcraft Aviation Corporation and for the next 5 years served successively as Project Engineer, Chief Engineer, and finally Vice-President. At Taylorcraft, he supervised the design, manufacture, and test of numerous personal aircraft intended for liaison, ambulance, and crop-dusting work. He was also concerned with a project for the Navy on radar-controlled buzz-bomb gliders, with airfoil designing, and with application of ceramic coatings to exhaust systems.

Not long after joining the Globe Corporation in 1945 as Chief Engineer, Mr. Wendt was elected Vice-President of Engineering for Globe's Aircraft Division. Early this past spring, he was also made General Manager in charge of the Globe plants in Joliet, Ill., Williams Bay, Wis., Oxnard, Calif., and Kingman, Ariz.

Mr. Wendt, who was born in Eden, N.Y., on June 14, 1911, became imbued with the idea of an aeronautical profession back in 1930, because it seemed to offer him the "most interesting profession available." But as he looks back over the years, he is unable to determine what might have been the high points of interest; he is, he says, "too busy each day to remember yesterday's interesting episodes."

Some of his education was accomplished in the evening at the Burgard School and the University of Buffalo, while he was working days at Curtiss Aeroplane and Motor Company. Some time later, he was granted a B.T.E. degree from the Allied Institute of Technology, where he is currently on the Board of Advisors.

During the 1930's and 1940's, Robert Wendt owned and flew personal planes. Nowadays, his hobbies, aside from aviation in general, are photography and speed boats. He and his wife, the former Gertrude McGuire, whom he married in 1938, are the parents of two sons, Robert, aged 11, and Gerald, aged 4.

Floyd J. Sweet, Lt. Col., U.S.A.F.

Dayton Section

An early interest in model building and glider flying automatically drew Lt. Col. Floyd J. Sweet, U.S.A.F., into an aeronautical career. The year 1930 was its formal beginning; that was the year in which he was awarded a Federation Aéronautique Internationale (F.A.I.) "C" Soaring Certificate. Seven years later, he received both his C.A.A. Commercial Glider Certificate and a B.S. degree in Aeronautical Engineering from the University of Michigan. He also holds a C.A.A. Private Pilot's Certificate, which he obtained in 1945, as well as a C.A.A. Glider Pilot Examiner Certificate.

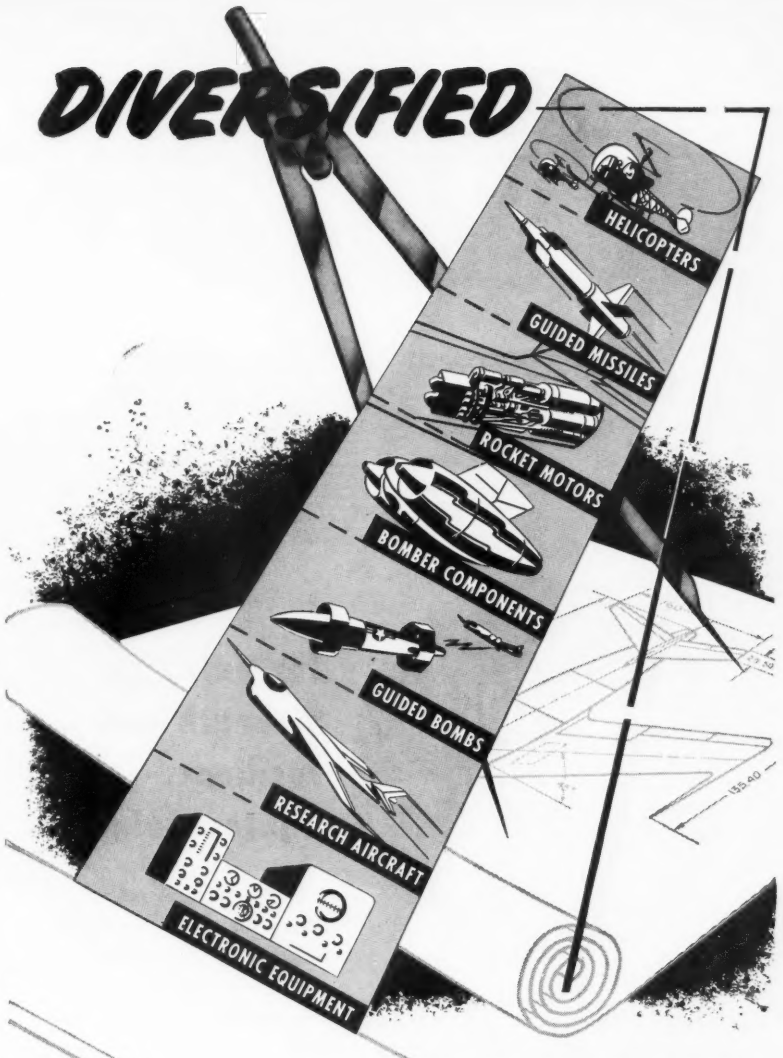
His first job, with the Eclipse Machine Division of Bendix Aviation Corporation as an Engineer specializing in detail design, was followed by his becoming Director of the Elmira (N.Y.) Aviation Ground School where he taught aviation trades. Elmira, incidentally, was

Colonel Sweet's home town; he was born there on June 29, 1914.

Colonel Sweet was called to duty early in 1941 as a reserve officer in the U.S. Army Air Corps. During his first 6 or 7 months in the service, he was Proof Officer at the Ordnance Department's Jefferson Proving Ground. Later that same year, he was transferred to the Air Corps Glider Training Program as Director of Ground and Pilot Training. In 1943, he was attached to the Air Materiel Command in the dual capacities of Glider Project Officer and Test Pilot. The next year, he was made Chief of the Weight Branch of A.M.C.'s Aircraft Laboratory. In 1945, he became Chief of the Glider Branch, Aircraft Laboratory. In 1946, he was appointed Chief of the Aircraft Laboratory's Cargo and Assault Airplane Unit, where he remained for the next 4 years. He took over his present assignment as Assistant to the Chief of the Aircraft Section, Weapons System Division, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, in 1951.

Colonel Sweet has experienced many outstanding events in his lifetime, but let him tell about some of them in his own words. "The most interesting episodes of my career have perhaps been since I have been stationed at Wright Field where I have been the Project Engineer and Glider Test Pilot on the XG-15, XG-18A, and XG-20 military gliders. As a Project Engineer, it has been extremely interesting to work with aircraft manufacturers in the development and improvement of gliders. It was doubly interesting in that I was able to perform most of the initial flight testing on these aircraft. A high light of this period was in 1949 when Gen. H. S. Vandenberg presented me with the Evans Trophy, an annual award for the greatest contribution by a glider pilot to the U.S. Air Force Glider Program. The greatest thrill in this field came during a flight testing of the XG-20, which was a 32,000-lb. gross-weight glider of all-metal construction. The most satisfaction was derived from my participation in the development of assault airplanes, the YC-122 and XC-123. Two early events are of interest, that of qualifying as a soaring pilot in 1930 at the age of 16 (I soloed my first airplane 11 years later) and of participating in my first National Soaring Contest a year later. (I have missed competing only twice since and have never missed attending a National Soaring Contest.)"

Colonel Sweet is Director of the Soaring Society of America and Chairman of the Soaring Society of Dayton, as well as a member of the National Sojourners and of Theta Xi fraternity. Aside from his long-standing love of soaring, he enjoys bowling, tennis, and swimming.



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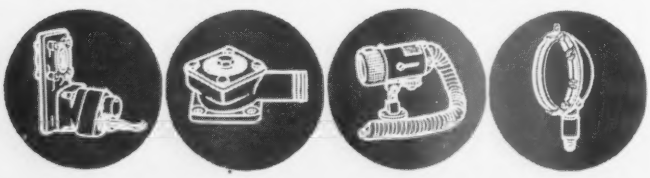

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Robert E. Hage

Seattle Section

Robert E. Hage as Senior Engineer, Preliminary Design Department, and Sales Engineer, Boeing Airplane Company, is a man with a three-way job to do. He is responsible, first, for the preliminary design of commercial and military aircraft; second, for the presentation of designs to air-line companies and Air Force agencies; and third, for supplying information on current status of Boeing bomber and missile projects to agencies of the Air Force.

Mr. Hage, despite his youth (he was born on March 24, 1917, in Seattle), has authored one book and coauthored another. The first one is his own book on *Jet Propulsion in Commercial Air Transportation*. The second one is a textbook, *Airplane Performance, Stability, and Control*, which he coauthored with Prof. Courtland D. Perkins, Chairman, Aeronautical Engineering Department, Princeton University.

After attending the University of Washington from 1934 to 1939 and receiving his B.S. degree in Aeronautical Engineering from there in 1939, he took his Master's degree in Aeronautical Engineering at the Massachusetts Institute of Technology. In 1940—the same year in which he completed his graduate work at M.I.T.—he married Virginia C. Hamilton. Mr. Hage is proud of his "four beautiful daughters": Virginia Elizabeth (Beth), aged 10; Pamela Charlotte (Pam), aged 8; Dana Hamilton (Dana), aged 5; and Mary Christine (Chris), aged 6 months.

As a boy, Mr. Hage was intrigued with the study of astronomy and the speculation of space travel. As a man, this interest centered itself on the "field of engineering which [to him] appeared to be developing the most rapidly." And so he went into aeronautical engineering.

His first 2 years in his chosen profession were spent as an Instructor in Aeronautical Engineering at the University of Washington. In 1942, he was appointed Chief of the Aircraft Laboratory, Aerodynamics Branch Air Materiel Command; here he was concerned with the evaluation of the performance and handling qualities of U.S.A.A.F. aircraft. (He was made an Air Force Major in 1944.)

Upon being discharged from the service in 1946, Mr. Hage joined Boeing Airplane Company as Senior Group Engineer in the Preliminary Design Department. Three years later, he was

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sent to Washington, D.C., as Scientific Warfare Adviser to the Weapons Systems Evaluation Group, Office of the Secretary of Defense. Last year, upon returning to Seattle, he assumed his present position.

Mr. Hage, a member of Sigma Xi, Tau Beta Pi, and Phi Gama Delta fraternities, lists these among his recreational activities: golf, tennis, gardening, and being at home with his family. He is presently constructing a tennis court in the back yard of his home. Incidentally, he holds a current C.A.A. Private Pilot Certificate.

Of all the various experiences that have made up Mr. Hage's life, he considers his "11 years of marriage" to be the most interesting. His year in the Nation's capital came second in his estimation with his fascinating work in the Weapons Systems Evaluation Group, sight-seeing with his family in and around the District of Columbia, and a view of the Federal Government in operation following in that order.

I.A.S. Sections

Baltimore Section

Hans Dehlinger for M. Francis Taylor, *Secretary*

The Baltimore Section wound up a successful season with their May 22 meeting, held on the campus of The Johns Hopkins University. Over 100 members and guests attended the combined dinner meeting, at which the newly elected officers for the coming season were announced and installed. Captain Higgins, of the U.S. Naval Post-Graduate School and Chairman for the season now ending, presided.

Officers for the coming season are as follows: Chairman, F. D. Jewett; Vice-Chairman, H. Pusin; Secretary, M. F. Taylor; and Treasurer, M. G. Hellert. These men are all with The Glenn L. Martin Company.

Speaker for the evening, William A. M. Burden, is both a Founder and Past-President of the I.A.S. A former Assistant Secretary of Commerce, he now serves in the capacity of Special Assistant to Secretary of the Air Force Finletter. He is the author of the book, *The Struggle for Airways in Latin America.*

Mr. Burden spoke on our Government's activity in research and development, particularly in relation to the Air Force. The speaker introduced his presentation by stressing the importance of achieving a high level of technical development in order to realize fully our technological potential and productive capacity. The speaker then discussed the various aspects of organization, policy, and administration.

Three separate groups cooperate in the Government's research and development program—universities, industry, and the Military Establishment with their respective emphases on research, production, and the establishment of objectives, weapons systems, and contracts. The overall program requires a wise spending of financial resources to extract the most from the best available resources, the speaker pointed out. In connection with awarding contracts, the speaker indicated the need to bring consistency to budget variation troubles.

Mr. Burden cited the importance of the I.A.S. in its liaison function among educational institutions, industry, and government as a significant influence in maintaining a healthy freedom of discussion. Orientation of the Government's research and development program is toward forming committees and holding panels, promoting competition and avoiding duplication. The speaker stated that many changes in the Air Force are required to improve research.

The speaker indicated the pressing need today for properly qualified engineers and scientists, as the supply is inadequate for our present military research and development program. In addition to the immediate need for increasing the country's military strength, emphasis is also placed on expanding the peacetime research effort to a maximum.

While the importance of modern research facilities is evident, Mr. Burden stressed that brains, devotion, and ability are definitely greater assets.

Boston Section

L. J. Nuttall, *Secretary*

The Boston Section completed the year's activities with its Annual Spring Dinner Meeting on June 20 at the Thomson Club in Nahant, Mass. The largest crowd of the year turned out for the cocktail hour sponsored by the Aircraft Gas Turbine Sections of the General Electric Company and for the roast turkey dinner and program.

In the absence of Prof. Hawthorne, Chairman of the Section, Vice-Chairman C. F. Savage of the Meter and Instrument Division, General Electric, introduced the speaker, Lt. Col. William H. Powell, U.S.A.F. Colonel Powell spent considerable time in the Korean theater of operations aboard a Navy aircraft carrier as part of the Navy-Air Force pilot exchange program and had plenty of interesting talk that covered all phases of it. The audience was surprised to find out all of the different types of aircraft that are in use in the Korean theater and what the uses are for each type. The talk also included a

Baltimore's Final 1950–1951 Meeting: *Some of the I.A.S. members and guests of the Baltimore Section present at the May 22 officer-installation meeting are shown in an informal pose. At the head table (background) are shown from left to right: J. W. Sweetser, Vice-President—Contracts, The Glenn L. Martin Company; C. C. Pearson, President and General Manager, Martin; William A. M. Burden, Special Assistant to the Secretary of the Air Force; Capt. George J. Higgins, U.S.N.R., Retiring Chairman, Baltimore Section; Frederic D. Jewett, Incoming Chairman, Baltimore Section; Mrs. Herman Pusin; and Herman Pusin, Incoming Vice-Chairman, Baltimore Section. In the foreground are: (left to right) W. W. Symington, Jr., Martin; W. D. van Zelm, van Zelm Associates; and E. E. Clark, Martin.*

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description of operational methods and tactics employed which emphasized the importance of air power in fighting a ground war.

The meeting was concluded with an Air Force movie on Korean activities. It well illustrated the points previously brought out by Colonel Powell. The program held the interest of everyone present and was well received.

Los Angeles Section

Milton A. Miner, *Secretary*

The Los Angeles Section had an interesting and well-attended dinner meeting on May 17, at which C. L. (Kelly) Johnson, Chief Research Engineer, Lockheed Aircraft Corporation, spoke on his trip to Korea. His subject, "A General Discussion of Jet Fighter Operation in Korea," dealt in an impartial manner with the problems of maintenance and repair of jet fighters in Korea, as well as a number of related topics such as the quality of Russian jets and their probable future developments in design and production.

The trip to Korea was organized by General B. W. Chidlaw of A.M.C. in order that both military and industrial leaders might witness first hand the operational problems of jet fighters in actual combat, as well as to study problems of supply, transport, etc.

Mr. Johnson reported that Wake Island was the scene of great air activity with some 60 trips per day passing through. At Tokyo, the party was briefed on the Korean picture. The following interesting facts were presented: airplanes have killed about 40 per cent of the enemy; our ground casualties have been in the ratio of about 1 to 4; our air casualties have been in the ratio of about 1 to 400; and this is the fourth largest war that the United States has fought.

In discussing fighter requirements, Mr. Johnson felt that designers should answer some serious questions before adding new equipment to airplanes, already heavily loaded. These were: (1) Is the equipment absolutely necessary? (2) Is it as important as more fuel and ammunition? Field limitations also have greatly reduced the effectiveness of some of the jet fighters in terms of the total amount of equipment carried. Taegu, which is one of the largest fields in the world, has 5,200-ft. runways.

Rocket take-offs are limited due to cost ($1,300 per shot) and the smoke that forces planes to take-off one at a time. A cheap, smokeless rocket is badly needed to improve this situation.

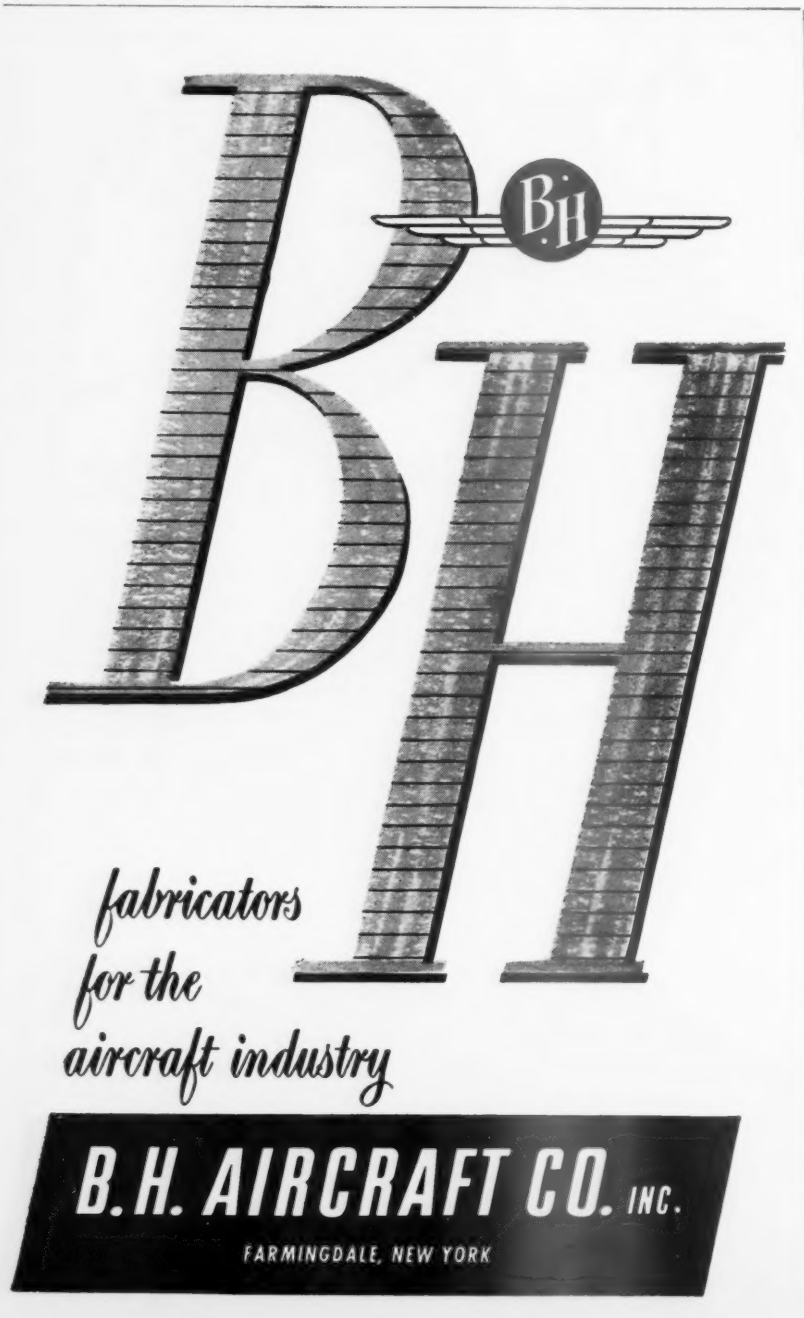
Many additional facts of general interest were also reported. Japan is the base for supplies; because of poor surface transport conditions, a great percentage of the supplies are flown in. Five hundred to 700 tons of supplies per day are flown to Korea. In an airdrop from a C-119, 5 tons were dropped in 5 sec. Evacuation of casualties by air is a large-scale operation. By March, over 100,000 badly wounded had been flown to Japan and to other base hospitals.

The speaker was high in his praise of the Far East Materiel Command for their ingenuity in making major repairs. They have rounded up many pieces of equipment that had been abandoned in the South Pacific and put them to good use. They also were making rather extensive modifications and major repairs.

Kelly Johnson showed a fine collection of colored slides of various phases of the trip. Of considerable interest were the shots of battle damage sustained by jet fighters that were still able to return to base. Also, many field revisions were made to meet actual operating requirements.

Mr. Johnson concluded by strongly stressing the importance of optimum performance and ease of maintenance even at the expense of sacrificing some of the newer gadgets and refinements that do not affect the performance.

An active question and answer session followed the talk.



On April 25, a specialists' meeting was held on the subject, "The Relationship of Applied Research to Design." The speaker was F. B. Bolte, Assistant Chief Research Engineer, North American Aviation, Inc.

Specialists' meetings in May included one on the 3rd and another on the 22nd. The May 3 meeting was on the subject, "Low Pressure Aerodynamics," and its speaker was Dr. S. A. Schaaf, Division of Mechanical Engineering, University of California at Berkeley. The May 22 meeting covered the subject, "Recent Applications of the Relaxation Methods to Engineering Problems." The speaker was Sir Richard Southwell.

Sir Richard is best known by engineers and physicists in connection with the formulation and development of powerful methods of relaxation which are finding increasingly widespread use in the solution of problems in all fields of science. He has had a distinguished career in teaching and research, having served as Professor of Engineering Science at Oxford and, until recently, as Rector of the Imperial College of Science and Technology in London. Also, he has taught mathematics at Cambridge and served as Superintendent of the Aerodynamics Department of the National Physics Laboratory.

Further Section activity in May also included the "Annual Test Hop," a successful informal dance, which was held on May 5.

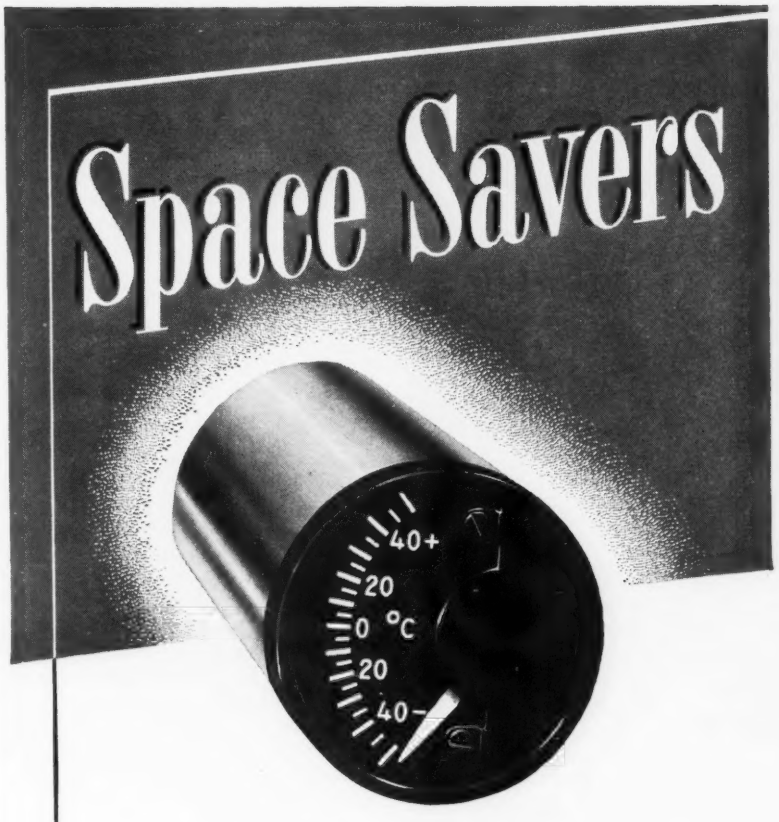
San Diego Section

W. H. Shutts, *Secretary*

The San Diego Section presented its Second Annual Aviation Award to Fred H. Rohr, President, Rohr Aircraft Corporation, at a banquet and civic gathering in the Auditorium of the House of Hospitality, Balboa Park, San Diego, on June 7.

This award is presented each year to the individual who has made the most outstanding contribution to the community of San Diego in the field of aviation during the previous year. The recipient of this award is selected by a committee of prominent San Diego businessmen.

Concerning Mr. Rohr's selection for this year's award, it was stated in part: "Mr. Rohr's contributions to the community have been many and varied, and while they were accomplished over a period of years, their beneficial effect on our community became profoundly evident in 1951. He organized a locally owned corporation which was successful in buying the assets of the Rohr Aircraft Corporation and through stock issues and credit arrangements was instrumental in permanently financing the new



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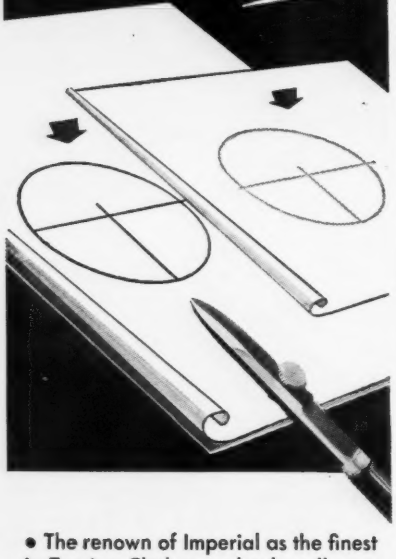

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corporation. This arrangement has made it possible for the Rohr Aircraft Corporation to play an important part in the current rearmament program, with profits remaining in our community. His many inventions, knowledge of production efficiency, administrative ability, have made Rohr Aircraft Corporation the world's largest producer of power packages for airplanes, and this has assured gainful employment for many residents of this area. Under his guidance there has been no loss of time due to labor-management disagreements.

"This outstanding leadership made it evident to the committee that Mr. Rohr should receive the San Diego Section of the Institute of the Aeronautical Sciences Aviation Award for 1951."

Mr. Rohr received the citation, beautifully inscribed on a parchment scroll, from San Diego Section Chairman W. T. Immenschuh. The principal address of the evening was given by Major R. H. Fleet.

Present at the banquet and presentation were 160 members and guests. In addition to top representatives of the local aircraft industry, there were also present a large delegation of community leaders headed by the mayor, president of the Chamber of Commerce, high-ranking officers from the Navy, Air Force, Coast Guard, and Marines, and prominent San Diego businessmen.

Seattle Section

Robert E. Hage, *Chairman*

The last meeting of the current year was held on June 7 at Sand Point Naval Air Station. The featured speaker was Clarence L. (Kelly) Johnson, Chief Research Engineer, Lockheed Aircraft Corporation, who in a talk on "A General Discussion of Jet Fighter Operation in Korea" described in detail his experiences during a recent visit to the Korean battlefront. One of the largest meetings of the year, Mr. Johnson's talk drew some 180 I.A.S. members for the dinner and program at the Naval facility.

D. B. (Ted) Martin, Preliminary Design Engineer, Boeing Airplane Company, and key member of the I.A.S. Program Committee, was presented with a suitably engraved desk set as the I.A.S. member in this locality who "contributed most to the advancement of the Institute" during the year. Mr. Martin was largely responsible for lining up programs and worked untiringly to make them the most successful in many years.

Earlier meetings this year included talks by top engineers from Boeing on jet-transport problems; the Wright Brothers paper presented by Dr. William Bollay, Technical Director, Aerophysics

Lockheed

SETS PACE IN CARGO FIELD

Look to Lockheed for the first cargo transport designed purely for turbo-prop power. It's the new L-206—answer to the U. S. Air Force request for greatly stepped-up range combined with speed, capacity and loadability.

Designed in 5 months the L-206 was the competition winner among 5 manufacturers. Far exceeding minimum specifications, it features numerous Lockheed innovations: a new streamlined full-rear opening for air drops... a pressurized cabin . . . clean interior, free of interfering protuberances . . . uniform tie-down fittings . . . integral loading ramp. The L-206 will have power conveyors in its truck-high floor, only 45" off ground.

What's going on at Lockheed?

Lockheed will whack into a billion dollar backlog when production starts in the newly opened plant in Marietta, Ga., now being tooled for the B-47 jet bomber. In Burbank assembly lines are being mechanized once again for faster jet production. New employees are being hired at the rate of 550 per week. Extensive plant expansion is now under way, including augmented facilities for advanced research.

What's being said about Lockheed?

AMERICAN AVIATION, July 9, 1951: "Constellations are now earning C&S (Chicago & Southern Air Lines) over 14c per plane mile before mail pay. Equipment reliability has been exceptional."

AERO DIGEST, June, 1951: "The Constellation, even after 12 years of life, is not now nearing the end of its cycle but is only on the edge of a virtually new era. When a company can produce an airplane for which it has a backlog of future production of 139 (April 1) units after 12 years, you know that that company has accomplished a major miracle of technical foresight, and that is, without flattery, the accolade of the Lockheed Constellation, one of the truly great airplanes of aviation history."

Leadership demands constant achievement

Every 80 minutes

a Lockheed Constellation sets a new record for dependability!

Over 30,000 times the *dependable* Constellation has crossed the broad Atlantic... setting a record of *more crossings than all other modern airliners combined.* And every 80 minutes a Constellation repeats the performance, piling experience on experience on experience.

Twenty years of Lockheed leadership back every Constellation. Next time you fly, overseas or at home, go by *experienced* Constellation.

DEPENDABILITY IS A 20-YEAR TRADITION—dramatically illustrated today by the Lockheed F-80 *Shooting Star*... which has flown more Korean combat sorties than all other fighters combined.

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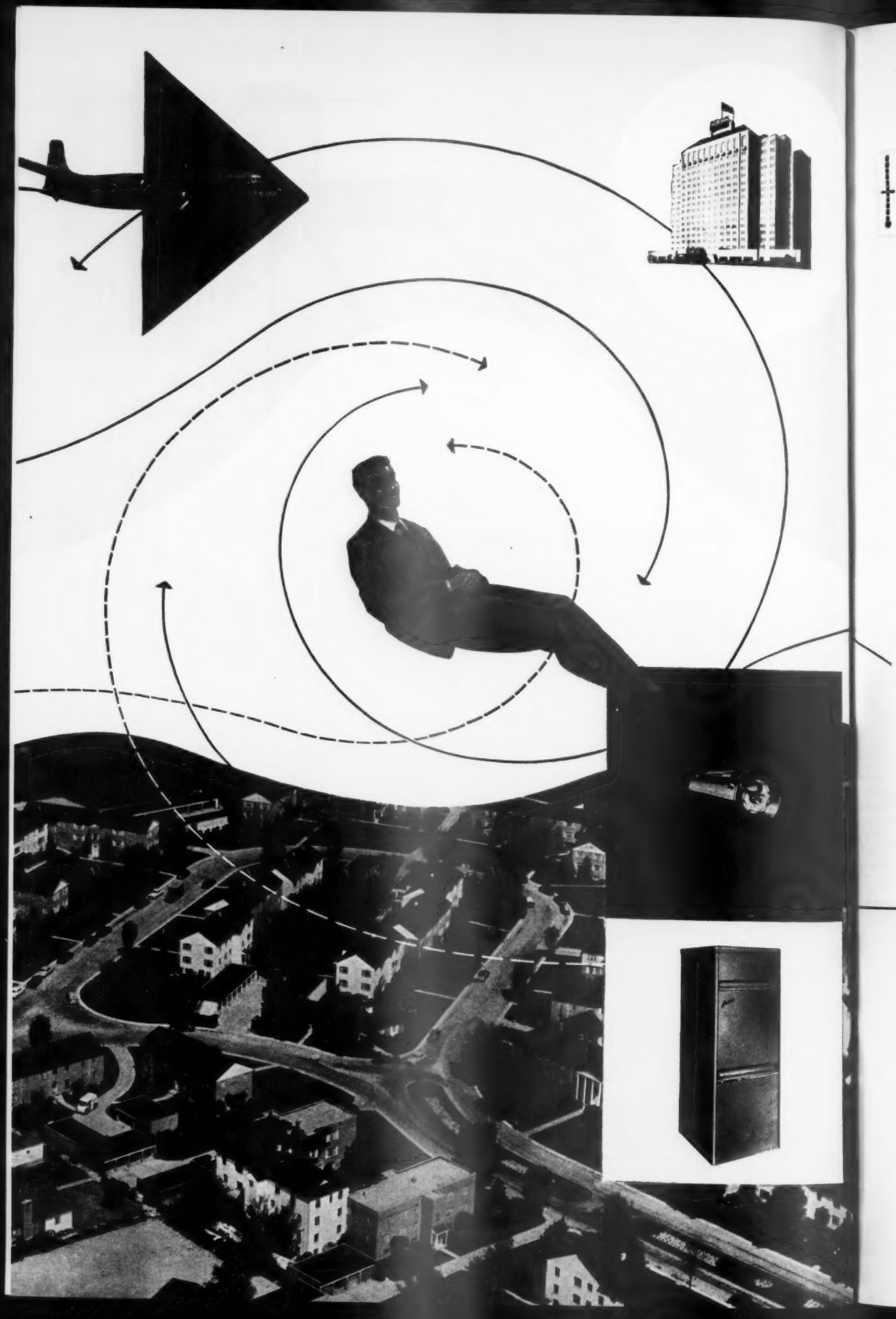

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Washington, D. C.: F. H. Scott, 4650 East-West Highway
Columbus, Ohio: Phil A. Miller; Frank Deak, USAF Coordinator, Engineering Development and Production, 400 Dublin Ave.
Toledo, Ohio: Headquarters

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Laboratory, North American Aviation, Inc.; and an illuminating talk on "Air Rescue" by the 1950 Octave Chanute Award winner, Capt. Donald B. MacDiarmid, U.S.C.G., Commanding Officer, U.S.C.G. Air Station, San Diego.

Chairman Robert E. Hage announced that the nominating committee was in the process of making choices for the next election slate.

Toronto Section

S. L. Britton, *Secretary*

The May 21 meeting took the form of a "members only" field trip to the School of Aviation Medicine, R.C.A.F., in Toronto.

The Chairman, H. C. Luttman, introduced the Commanding Officer of the R.C.A.F. Station, Wing Commander B. R. Brown, who welcomed the 45 members attending the lecture tour. Wing Commander Brown then briefly summarized the brilliant career of Dr. W. R. Franks, who is a retired senior R.C.A.F. officer acting as Medical Consultant to the School of Aviation Medicine.

Dr. Franks gave a brief talk on the problems brought about by subjecting the human body to the high-load factors and speed of the present-day combat aircraft. He stressed the need for direct liaison between the aircraft designers and engineers and the doctors and scientists who were responsible for determining the limitations of human endurance. He pointed out the need for a new set of aircraft design criteria based on the data that have been accumulated by the men who have been studying the Human Endurance Problem.

Many design trends, it was pointed out, had been benefited directly by the designer's having these data available, thereby eliminating various design alternatives. Dr. Franks then explained the route of the tour and generally described what would be found in each of the sections to be visited.

The party was broken down into several groups who took the following routes under the guidance of capable R.C.A.F. senior N.C.O.'s: Decompression Chamber and Oxygen Equipment; Night Vision School; Air/Sea Rescue Facilities; Centrifuge; High Temperature and Humidity Chamber; Low Temperature Room; Sound Rooms; and High Altitude Chambers.

The members then adjourned to the Officers Mess where refreshments were served.

Student Branches

Academy of Aeronautics

On June 28, two films, *McDonnell Helicopters* and *Operation Airborne*, were shown to the 19 attending members. Chairman Bernard Buc presided.

The Aeronautical University, Inc.

A Shell Oil Company film, *Flight Log*, was shown to the 22 persons who attended the May 2 meeting. Chairman Woody Kokita presided.

An election of officers was held on May 17 with the following results: Chairman, Eugene A. Czeck; Vice-Chairman, John F. Jeglia; Secretary, Donald E. Ronning; and Treasurer, John F. Pavlick. Alfred F. Stott was chosen as the new Honorary Chairman. A film, *The XF-92A*, was shown. Outgoing Secretary John F. Jeglia presided; 35 persons were present.

Cal-Aero Technical Institute

A Kaiser Steel Corporation film release, *Strength in the West*, was shown on June 7. Chairman Charles Reid presided; 50 persons were in attendance.

California State Polytechnic College

Chairman Milo V. Price presided at the May 22 meeting at which Student Member A. K. Andersen spoke on "The Processing of Color Films for Data Recording." Two films, *Cavalcade of Aviation* and *Design for Flying* (the latter one from Douglas Aircraft Company, Inc.), were shown. The following officers were elected: Chairman, Herbert E. Pearce; Vice-Chairman, David P. Fuller; Corresponding Secretary, V. Keith Putnam; Recording Secretary, Robert A. Wright; and Treasurer, Koonwah Lim. Thirty-four members were present.

Outgoing Chairman Price opened the Second Annual Dinner Banquet on May 26. Lester W. Gustafson, Honorary Adviser of the Student Branch and Head of Cal Poly's Aeronautics Department, presented the Lecture and Scholastic Awards to Clinton P. Sherburne, outgoing Vice-Chairman, and J. Richard Campbell, respectively. After a few words by E. W. Robischon, I.A.S. Western Manager, Kermit E. Van Every, Head, Aerodynamics Department, Douglas Aircraft Company, spoke on "Aerodynamics of High Speed Flight." The chair was then turned over to the incoming Chairman, Herbert E. Pearce, who introduced the other new officers and adjourned the meeting. There were 70 members and guests present.

Carnegie Institute of Technology

An election of officers was held on May 29 with the following results: Chairman, Carl Zorowski; and Secretary-Treasurer, Dale Startzell. Chairman Frank J. Stodolsky presided; 12 persons were present.

Cal Poly's Second Annual Dinner Banquet: *Shown with four of the five newly elected officers of the California State Polytechnic College Student Branch are E. W. Robischon, I.A.S. Western Manager; Kermit E. Van Every, Head, Aerodynamics Department, Douglas Aircraft Company, Inc.; and Lester W. Gustafson, Head of Cal Poly's Aeronautics Department. Pictured from left to right are: Koonwah Lim, Treasurer; Mr. Robischon; Herbert E. Pearce, Chairman; Mr. Van Every; Robert A. Wright, Recording Secretary; Mr. Gustafson; and David P. Fuller, Vice Chairman. V. Keith Putnam, Corresponding Secretary, is not included in the picture.*

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University of Detroit

On June 4, the incoming Chairman George P. Himes, called the meeting to order and announced the names of the other new officers for the coming year. These included: Vice-Chairman, T. E. Stuck; Secretary, C. J. Stim; and Treasurer, J. L. Shea. The new Faculty Adviser, Dr. Frederick W. Ross, Professor of Aeronautical Engineering, was introduced. As speaker of the evening, Dr. Ross presented a lecture on "Supersonic Flow Patterns by Hydraulic Analogy." The talk was supplemented by a motion picture on *Hydraulic Flow in Shallow Channels*. Seventeen persons were in attendance.

The Ohio State University

During a recent election, the following men were voted into office for the 1951–1952 school year: Chairman, Richard G. Docken; Vice-Chairman, Richard E. Larson; Secretary, Odus Burgraff; and Treasurer, William H. Siegfried.

Virginia Polytechnic Institute

As a result of a recent election, the following men will take office: Chairman, Elden S. Cornette; Vice-Chairman, Jeffrey S. Deutsch; Secretary, Perry W. Hanson; and Treasurer, Bernard P. Cook.

West Virginia University

Chairman Sam Hill opened the May 16 meeting at which ten members and one guest were present. An election of officers was held with the following results: Chairman, Eugene Fourney; Vice-Chairman, Richard Kingsland; Secretary-Treasurer, James Carpenter; and Corresponding Secretary, Robert J. Weaver. Professor Leon Z. Seltzer is the Honorary Chairman. The meeting was brought to an end with the showing of a U.S. Air Force film, *Look to the Sky*.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

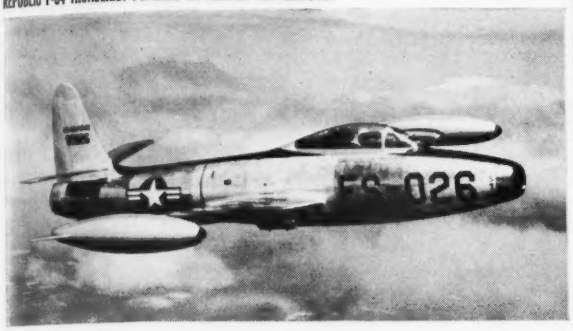
Elected to Associate Fellow Grade

Lafita Babio, Felipe, Ae.E., Dir. General, National Institute of Aero. Research (Madrid).

Leverett, Miles C., Sc.D., Engineering Mgr., ANP Project, General Electric Co.

Wood, Lysle A., B.S., Chief Engineer, Boeing Airplane Co. (Seattle).

REPUBLIC F-84 THUNDERJET POWERED BY ALLISON J35 TURBO-JET



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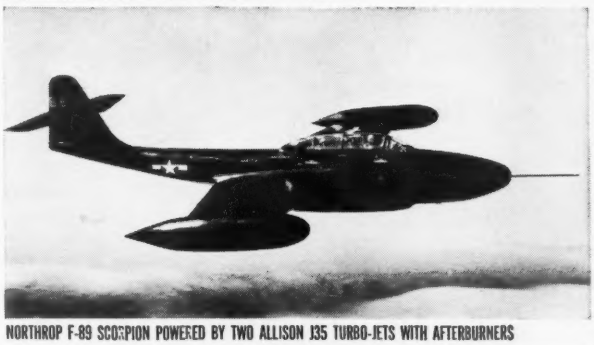
Navy sponsored Allison T40 twin Turbo-Prop engines are adding to Allison experience in two Navy planes. The T38 single engine Turbo-Prop in the Turbo-Liner, America's first turbine transport, is now undergoing tests at Edwards Air Force Base.

It's experience that counts—and these turbine engines have it where it counts most—in the air—in these airplanes.

GRUMMAN F9F-3 PANTHER POWERED BY ALLISON J33 TURBO-JET



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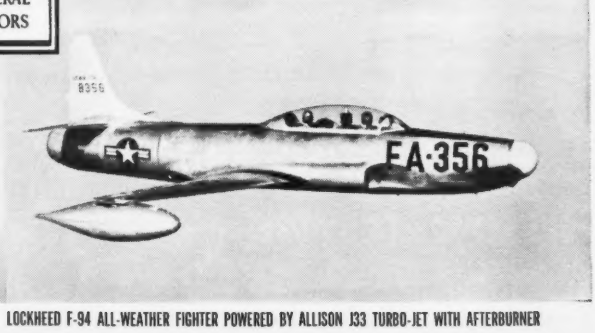

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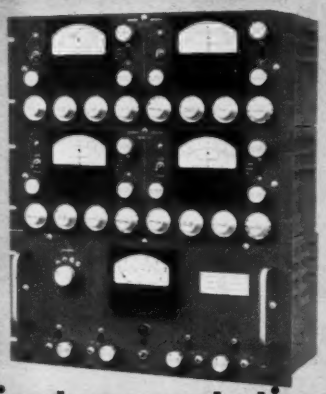
four-channel



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Transferred to Associate Fellow Grade

Bennett, Dwight H., B.S. in M.E. (Aero.), Asst. Project Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Greenwood, Marvin H., M.S. in M.E., Vice-President, Engineering & Sales, Anderson, Greenwood & Co.

Stolarik, Eugene, M.S., Assoc. Prof. & Asst. to the Chairman of the Aero. Engineering Dept., University of Minnesota.

Stott, Alfred F., Dean of Engineering & Personnel Dir., The Aero. University, Inc.

Wolfsohn, Robert S., M.A.E., Major, U.S.A.F.; Chief, Field Liaison Branch, Directorate of Research, Hdqs. A.R.D.C. (Baltimore).

Elected to MEMBER Grade

Adrion, Harold O., B.S. in Ae.E., Engineer-Power Plants, Chance Vought Aircraft Div., United Aircraft Corp.

Black, Knox C., Ph.D., Technical Adviser to Commander, Naval Air Development Center (Johnsville).

Burgess, Neil, M.S.E.E., Asst. Mgr. of Engineering, Aircraft Gas Turbine Div., General Electric Co.

Comstock, William P., Technical Supervisor, Royal Liverpool Ins. Group.

Cordon, Frank R., B. of M.E., Senior Flight Development Engineer, A. V. Roe Canada Ltd. (Malton).

Elder, Robert A., B.S., Colonel, U.S.A.F., Chief of AMC, Air Technical Liaison Branch (ATLO), Hdqs., U.S.A.F. (Europe).

Evans, Lawrence G., M.A., Senior Aerodynamicist, de Havilland Propellers, Ltd.

Gedeon, Geza, Dr.Ae.Sc., Instructor in Technical Subjects, Indiana Technical College.

Girault, Lawrence J., Designer—Naval Aircraft, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Hazlett, William D., Self-employed—Manufacturers' Representative (Dayton area).

Holman, Jerry A., B.S.M.E., Research & Development Engineer, Goodyear Aircraft Corp.

Lilly, Alexander John, Chief Test Pilot, Canadair, Ltd. (Montreal).

Miller, Herman, A.E., Chief, Transonic Tunnel Branch, Propulsion Wind Tunnel, AEDC, ARO, Inc.

Moore, Francis W., Supervisor—Engineering Services, Canadian Wright, Ltd.

Morrison, John D., B.S.M.E., Section Engineer, General Electric Co.

Niewald, Roy J., B.S. in A.E., Aerodynamic Scientist, N.A.C.A. (Washington, D.C.).

Pruden, F. W., B.Sc., Group Leader, in charge of High-Speed Aerodynamics, National Research Council (Ottawa).

Richards, E. J., M.A., Prof. of Aero. Engineering, University of Southampton.

Rock, Edward A., B.S., Power-Plant Installation Engineer-Staff, Boeing Airplane Co. (Seattle).

Rockliff, Robert J., B.E., B.Sc., Scientific Officer, Aero. Research Labs., Dept. of Supply, Australian Commonwealth Govt.

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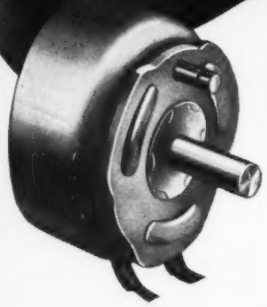

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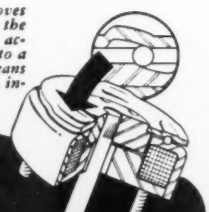

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Skidmore, Walter H., B.S. in E.E., Chief, Aircraft Instrument Engineering Group, Western Electrical Instrument Corp.

Stewart, Charles E., Design Co-ordinator, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Sulkin, Maurice A., B.S.M.E. (Aero.), Chief Thermodynamicist, North American Aviation, Inc.

Wilks, Raymond, Chief Aerodynamicist, Blackburn & General Aircraft, Ltd.

Transferred to MEMBER Grade

Bird, King D., B. of Ae.E., Sr. Engineer, Applied Physics Lab., The Johns Hopkins University.

Dauwalter, Chadwick S., B.S.M.E., Research Engineer "B," Aerophysics Lab., North American Aviation, Inc.

Fuhrman, Robert A., B.S.E. in Ae.E., Project Engineer & Instructor, Test Pilot Training Div., Naval Air Test Center (Patuxent River).

Kutsay, Ali U., M.S. in Ae.E., Project Engineer, Sonntag Scientific Corp.

Sturrock, James P., M.S. in Ae.E., Captain, U.S.A.F.; assigned to Hdqs., Research & Development Command, Wright-Patterson Air Force Base.

Elected to Associate Member Grade

Fraser, Robert J., Sales Representative, Aviation Hardware Div., Clary Multiplier Corp.

Elected to Technical Member Grade

Boggs, Julius L., Engineer "A," Testing Div., Power Plant & Mechanical Design Group, Douglas Aircraft Co., Inc. (Santa Monica).

Emer, Sam, Design Draftsman, A. V. Roe Canada Ltd. (Malton).

Godts, Jose, Civ. Ing., Technical Chief, Avions Fairey, S.A.

Reif, James P., Flight Engineer, United Air Lines, Inc.

Straiton, John M., B.S., Jr. Aerodynamics Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Trittipoe, Jack H., B.S., Draftsman, The Globe Corp., Aircraft Div.

Transferred to Technical Member Grade

Ackerman, William H., Jr., Instructor, Academy of Aeronautics, Inc.

Alley, Donald J., M.S. in A.E., Dynamics Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Bakalar, David L., B.Aero.E., Aero. Engineer, Lockheed Aircraft Corp.

Bakemeyer, William F., B.Sc. & M.S., Aerophysics Engineer, Consolidated Vultee Aircraft Corp. (Fort Worth).

Baldwin, Mark, B.S., 2nd Lt. & Maintenance Engineer, U.S.A.F.

(*Continued on page 116*)

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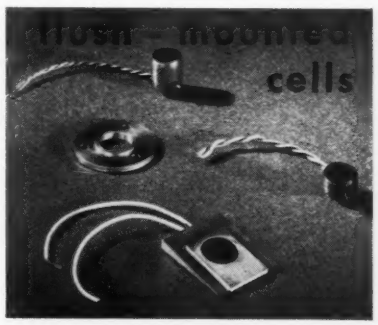

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A Guide to the Current Literature of Aeronautical Research and Engineering

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Aerodynamics (2)

Some Aspects of Flight Research. Handel Davies. *Royal Aeronautical Society, Journal*, Vol. 55, No. 486, June, 1951, pp. 325–357, Discussion, pp. 357–361, illus. 21 references. Developments in flight research concerned with aircraft drag reduction, stability and control problems, and general aerodynamics.

Catalogue of Aerodynamic Measurements. J. H. Greidanus and A. C. de Kock. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Report No. F.64*, July, 1950. 46 pp., illus.

Proposed classification system for aerodynamic data from wind-tunnel and free-flight measurements. Included are lists of symbols and abbreviations; mathematical symbols and units; symbols for forces, moments, and related quantities; and symbols for incompressible, subsonic, transonic, and supersonic flow, and boundary-layer characteristics.

Summary of the First Sample of VGH Data of Normal Accelerations and Associated Operating Conditions on Two Four-Engine Transport Airplanes in Commercial Operations. Robert L. McDougal. *U.S., N.A.C.A., Research Memorandum No. L50D28a*, August 28, 1950. 5 pp., illus. 1 reference.

Wind-Tunnel Tests on the Folland E.28/40; High-Wing Monoplane with a Variable-Incidence Wing. I. R. Hills, R. H. Whitely, and F. N. Kirk. **II—Further Wind-Tunnel Tests on the Folland E.28/40—Without Ground.** E. Priestley, H. V. Becker, and E. C. Brown. **III—Further Wind Tunnel Tests on the Folland E.28/40—With Ground.** H. V. Becker, R. L. Jeffries, and M. A. Morrison. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2456*, 1951 (January, 1944). 63 pp., illus., tables. 8 references. British Information Services, New York. $2.50.

Wind-Tunnel Tests on the Supermarine S.12/40, a Monoplane with a Variable Incidence Wing. H. V. Becker, R. Hills, and M. A. Morrison. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2454*, 1951 (June, 1944). 35 pp., illus., tables. 3 references. British Information Services, New York. $1.50.

Further Wind-Tunnel Tests on the Supermarine S.12/40, a Monoplane with a Variable Incidence Wing. H. V. Becker, R. Hills, and H. Hogg. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2455*, 1951 (May, 1944). 14 pp., illus., tables. 2 references. British Information Services, New York. $0.75.

BOUNDARY LAYER

Investigation of Interaction Effects Arising from Side-Wall Boundary Layers in Supersonic Wind-Tunnel Tests of Airfoils. K. R. Czarnecki and C. F. Schueller. *U.S., N.A.C.A., Research Memorandum No. L8G27*, November 3, 1948. 27 pp., illus. 1 reference. Study of tunnel boundary-layer effect on the flow over models mounted directly from the wall; propagation of disturbances in the boundary layer.

Investigation of Operating Pressure Ratio of a Supersonic Wind Tunnel Utilizing Distributed Boundary-Layer Suction in Test Section. C. B. Cohen and A. S. Valerino. *U.S., N.A.C.A., Research Memorandum No. E50H04*, November 1, 1950. 39 pp., illus. 1 reference.

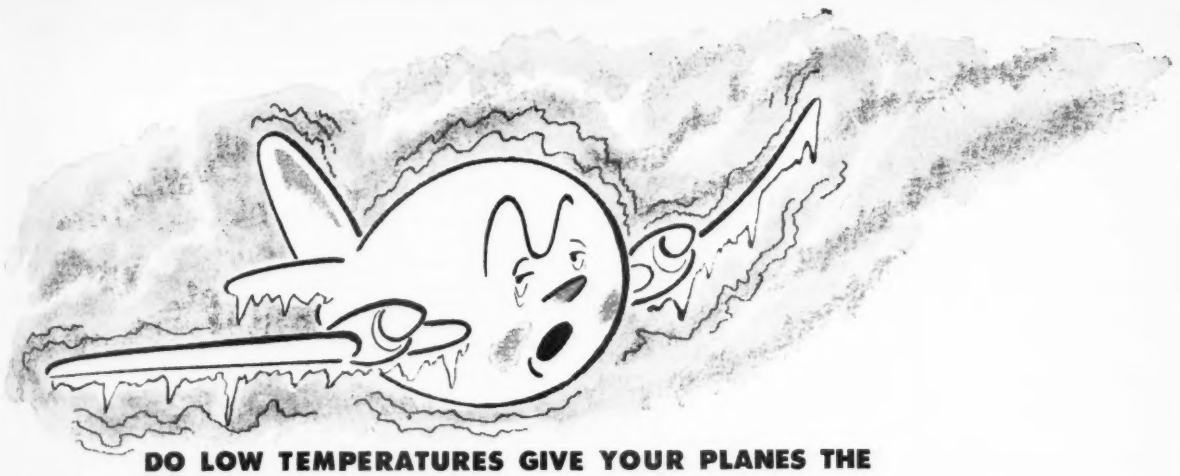
Investigation at $M = 2.0$ in the N.A.C.A. 3.84- by 10-in. supersonic tunnel to assess boundary-layer removal by continuous suction as a means of reducing separation losses. Schlieren photographs show the form of the terminal shock-wave configurations.

An Approximate Solution of the Laminar Boundary Layer Equation. Tetsushi Okamoto. *Tokyo Institute of Technology, Bulletin, Series B*, No. 3, 1950, pp. 227–232, illus. 8 references.

An approximate method of solution of Pohlhausen's boundary-layer equation in the region of retarded flow and approaching the transition point. The velocity profile is expressed as a quintic equation in which the five coefficients are determined from the boundary conditions. The solution is compared with known solutions.

Pohlhausen's Method for Three-Dimensional Laminar Boundary Layers. J. C. Cooke. *Aeronautical Quarterly*, Vol. 3, Part 1, May, 1951, pp. 51–60, illus. 13 references.

The von Kármán-Pohlhausen boundary-layer method was extended by Wild to obtain an approximate solution of the boundary layer on an infinite yawed cylinder. Cooke considers a yawed infinite cylinder when the potential flow normal to the



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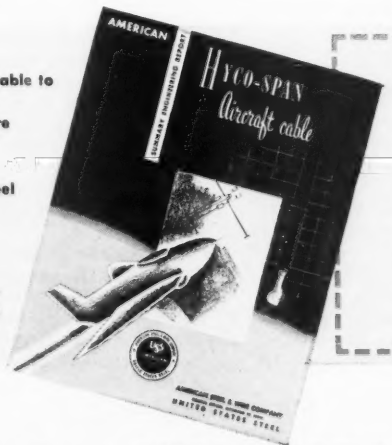

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generators is of the form $U = cx^m$. Since an exact solution is known for this case, the analysis provides a check of the method.

A Method for the Calculation of the Turbulent Boundary Layer in a Pressure Gradient. Paul S. Granville. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 752,* May, 1951. 40 pp., illus. 27 references.

Development of an equation for the variation of the shape of a velocity profile in the boundary layer. New relations are formulated for the variation in pressure gradient with the shearing stress at the wall and the integral of the shearing stresses across the boundary layer. A moment-of-momentum equation, modified by including the shearing-stress terms, gives a suitable auxiliary equation, which, when used with the von Kármán momentum equation, yields an analysis of the turbulent boundary layer in incompressible flow.

Comparison of Theoretical and Experimental Results for the Turbulent Boundary Layer in Supersonic Flow Along a Flat Plate. Carlo Ferrari. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 555–564, illus. 5 references.

CONTROL SURFACES

Experiments on the Balancing of Ailerons by Geared Tabs and Trailing-Edge Strips. L. W. Bryant, C. H. Burge, N. E. Sweeting, and J. R. Greening. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2510,* 1951 (April 5, 1941). 29 pp., illus., tables. 2 references. British Information Services, New York. $1.25. Tests on a $^1/_2$-scale model of $^2/_3$ of the Spitfire wing at a wind speed of 60 ft. per sec. with and without trailing-edge strips, with four sizes of tabs set at angles between $\pm 20°$.

Aileron Tests on a Spitfire. D. E. Morris and M. B. Morgan. **Appendix: Comparison Between Calculated and Experimental Rolling Power on the Spitfire.** F. Grinsted. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2507,* 1951 (April, 1941). 11 pp., illus. 8 references. British Information Services, New York. $0.65. Results of tests to study poor rolling characteristics at a speed of 400 m.p.h.

Wind-Tunnel Investigation of Fin and Rudder Accidents on Heavy Bombers (Halifax and Lancaster). C. H. E. Warren and J. A. Kirk. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2479,* 1951 (August, 1943). 26 pp., illus., tables. British Information Services, New York. $1.25.

Tests in the R.A.E. $11^1/_2$- by $8^1/_2$-ft. closed-jet tunnel to investigate rudder overbalance and directional stability at low speeds and large angles of sideslip, and modifications to improve stability.

Some Wind-Tunnel Developments of the Spoiler As a Form of Lateral Control. W. S. Coleman and G. H. Tidbury. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2586,* 1951 (November, 1942). 20 pp., illus. 10 references. Investigation of the static rolling, yawing, and hinge moments on hinged-plate and circular-arc spoilers.

FLUID MECHANICS & AERODYNAMIC THEORY

Stream Functions for Three-Dimensional Flows. J. H. Giese. *Journal of Mathematics and Physics*, Vol. 30, No. 1, April, 1951, pp. 31–35. 7 references.

Steady, nonviscous, adiabatic three-dimensional flows with vorticity can be described by two stream functions. The two general stream functions are analyzed, and a method is developed for verifying the variational principle.

Applicability of the Hypersonic Similarity Rule to Pressure Distributions Which Include the Effects of Rotation for Bodies of Revolution at Zero Angle of Attack. Vernon J. Rossow. *U.S., N.A.C.A., Technical Note No. 2399,* June, 1951. 28 pp., illus. 6 references.

Nonsteady Supersonic Flow About Pointed Bodies of Revolution. William H. Dorrance. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 505–511, 542, illus. 13 references.

Development of the general potential for the harmonic motion of a slender pointed body of revolution in a steady supersonic stream and of the doublet potential for low-frequency harmonic oscillations. Calculated examples illustrate the variation of stability derivatives with Mach Number for $M = 1.3$–2.3. The examples show how the derivatives can be modified by altering the shape of the body.

Readers' Forum: Note on Sphere Drag Data. Frederick S. Sherman. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, p. 566, illus. 1 reference.

Readers' Forum: Turbulent Diffusion from a Source in Turbulent Shear Flow. J. O. Hinze. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 565, 566. 1 reference. Diffusion by continuous movements as a factor explaining skewness in transverse temperature distributions behind a fine heated wire.

Similarity Laws for Slender Bodies of Revolution in Hypersonic Flows. Stanford E. Neice and Dorris M. Ehret. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 527–530, 568, illus. 6 references.

Evaluation of the validity of the hypersonic similarity law for nonlifting bodies of revolution. Pressure distributions obtained by applying the law are compared with those calculated by the method of characteristics. A similarity law is obtained for bodies of revolution at angle of attack.

Reduction of Supersonic Drag. *Aeronautics*, Vol. 24, No. 5, June, 1951, pp. 50, 51, illus.

Aerodynamics concerned with a recent French patent that states that use of a special fairing reduces the shock-wave drag of supersonic projectiles and rockets. A sharp-nosed body is surrounded by a fairing—the whole acting as a multishock supersonic diffuser. The limitations and features of this design are examined; a brief analysis of shock-wave interaction in a Busemann biplane explains the aerodynamics of the design principle.

Linearized Theory of Supersonic Flow. Lecture Given by Sydney Goldstein; Prepared by S. I. Pai. *Maryland, University, Institute for Fluid Dynamics and Applied Mathematics, Lecture Series No. 2,* 1950. 22 pp., illus. 12 references.

Development of the linearized theory for steady, supersonic motion. The analysis is based on the kinetic theory of gases but neglects the influences of viscosity and heat conduction. Experimental data are used to predict the kind and position of discontinuities. Methods of solution include the source-sink method, reduction of the potential problem, and the Heaviside operational method. Procedures for improving the solutions are offered.

A High Intensity Source for the Molecular Beam. I—Theoretical. Arthur Kantrowitz and Jerry Grey. **II—Experimental.** G. B. Kistiakowsky and William P. Slichter. *Review of Scientific Instruments*, Vol. 22, No. 5, May, 1951, pp. 328–337, illus. 9 references.

I. Theoretical design study and performance estimates of a nozzle-type source of a molecular beam. The first slit (width = 1 mean free path) is placed in the flow from the miniature supersonic nozzle (design $M = 4.0$) in a position coaxial with the final beam. A high Mach Number is produced at the first slit and lower Mach Numbers are produced at all other points. **II.** Construction and operation of the nozzle according to theory in Part I and of the detection apparatus. Tests made at various supply pressures showed limitations of the design.

Note on the Application of the Linearised Theory for Compressible Flow to Transonic Speeds. A. Robinson and A. D. Young. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2399,* 1951 (January, 1947). 6 pp., illus. 7 references. British Information Services, New York. $0.35.

For finite aspect ratio the linearized theory of compressible flow remains consistent theoretically in the transonic region, although its predictions may deviate from experimental results. The variation in the theoretical lift-curve slope of an airfoil of finite span is considered as the Mach Number increases from less than 1.0 to greater than 1.0; the slope remains finite and continuous.

Mathematical Methods Used in the Statistical Theory of Turbulence: Harmonic Analysis. Lecture Given by J. Kampé de Fériet; Prepared by S. I. Pai. **Appendix I—Non-Linearity of the Space S.** E. Zarantonello. **Appendix II—Example of Fourier Transform of an Orthonormal Set in a Bounded Domain.** S. I. Pai. *Maryland University, Institute for Fluid Dynamics and Applied Mathematics, Lecture Series No. 1,* 1950. 108 pp., illus. 9 references.

Mathematical basis of harmonic analysis of the theory of the spectrum of homogeneous turbulence. Topics covered include the monotonous nondecreasing functions, the Riemann-Stieltjes integral and Fourier transform of a function of class L, Fourier fundamental theorem, inversion formulas for the Fourier-Stieltjes integral and for the transform of a function of class $L(-\infty, \infty)$,

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and the Fourier transform of a function of class L^2 in N-dimensional space. In the latter topic the Hilbert space is the natural background. In Appendix I, the pair of functions of the nonlinear space S is constructed.

Introduction to Some Topics on Turbulence. Lecture Given by F. N. Frenkiel; Prepared by S. I. Pai. *Maryland University, Institute for Fluid Dynamics and Applied Mathematics, Lecture Series No. 3*, 1950. 103 pp., illus. 60 references.

Theory and experimental measurements of turbulent diffusion; statistical kinematics of turbulence; the von Kármán-Howarth equation; measurement of fluid flow by hot-wire anemometry; one-dimensional spectra of turbulence, decay of isotropic turbulence. The development of the statistical theory of turbulence by G. I. Taylor is reviewed.

On Stability and Turbulence of Fluid Flows. Werner Heisenberg. (*Annalen der Physik*, Vol. 74, No. 15, 1924, pp. 577–627.) *U.S., N.A.C.A., Technical Memorandum No. 1291*, June, 1951. 60 pp., illus. 17 references.

Review of results of previous studies on the stability problem. Criteria are set up for stable and unstable characteristics of a velocity profile; methods are developed for the solution of the stability equation and for the calculation of the critical Reynolds Number for unstable profiles. A complete calculation of the parabola profile illustrates the solution technique. Differential equations are derived for turbulent motion of the flow between two parallel walls with certain simplifying assumptions; the problem is idealized to permit a mathematical analysis by Stoke's equation.

Mechanism of Turbulent Fluid Motion. Max Munk. *Aero Digest*, Vol. 62, No. 6, June, 1951, pp. 99–108, illus. Nonmathematical description of the mechanism that produces turbulence.

INTERNAL FLOW

Flow Through Cascades in Tandem. William E. Spraglin. *U.S., N.A.C.A., Technical Note No. 2393*, June, 1951. 44 pp., illus. 8 references.

Methods of solution are developed for the direct and inverse problems of the two-dimensional flow of an incompressible inviscid fluid through two cascades in tandem. The solution employs the method of conformal transformation of the tandem cascade into a standard doubly connected region for which the flow is known. The first stage of the transform changes the tandem cascade into a two-dimensional biplane; the standard doubly connected region is that between two concentric circles.

Axisymmetric Supersonic Flow in Rotating Impellers. Arthur W. Goldstein. *U.S., N.A.C.A., Technical Note No. 2388*, June, 1951. 36 pp., illus. 4 references.

Equations, useful for impeller designs with closely spaced blades, for isentropic, frictionless, axisymmetric flow in rotating impellers, considering blade thickness and blade surface-function. The effects of prerotation of the gas, blade turning rate, gas velocity at blade tips, blade thickness, and leading-edge sweep on the internal flow and work input are investigated in several configurations.

Performance of 24-Inch Supersonic Axial-Flow Compressor in Air. I—Performance of Compressor Rotor at Design Tip Speed of 1600 Feet Per Second. William K. Ritter and Irving A. Johnson. *U.S., N.A.C.A., Research Memorandum No. E7L10*, May 17, 1948. 31 pp., illus. 5 references.

Investigation of Blade-Row Flow Distributions in Axial-Flow-Compressor Stage Consisting of Guide Vanes and Rotor-Blade Row. John J. Mahoney, Paul D. Dugan, Raymond E. Budinger, and H. Fred Goelzer. *U.S., N.A.C.A., Research Memorandum No. E50G12*, November 28, 1950. 54 pp., illus. 8 references.

Investigation to Determine Contraction Ratio for Supersonic-Compressor Rotor. Linwood C. Wright. *U.S., N.A.C.A., Research Memorandum No. E7L23*, April 30, 1948. 14 pp., illus. 3 references.

Analysis, based on cascade contraction-ratio theory, to determine the limiting contraction ratio. The ratio can be approximated by an expression involving blade gap, entrance flow angle, flow angle at $(t/c)_{max.}$ of blade, number of blades, and $(t/c)_{max.}$ of blade. The theory was checked experimentally by tests on four contraction-ratio configurations of a two-dimensional cascade in an open-jet supersonic wind tunnel.

Investigation of an Experimental Supersonic Axial-Flow Compressor. John R. Erwin, Linwood C. Wright, and Arthur Kantrowitz. *U.S., N.A.C.A., Research Memorandum No. L6J01b*, August 7, 1947. 58 pp., illus. 5 references.

Experimental investigation of a single-stage supersonic axial-flow compressor with a pressure ratio of 2.9 to determine operational efficiency when a normal shock occurs within the rotor passage and to verify predicted pressure ratios and design theory.

Performance Investigations of a Large Centrifugal Compressor from an Experimental Turbojet Engine. Ambrose Ginsburg, John W. R. Creagh, and William K. Ritter. *U.S., N.A.C.A., Research Memorandum No. E8H13*, October 18, 1948. 54 pp., illus. 6 references.

Performance characteristics and airflow analysis of a compressor having a single-entry impeller with an inlet-to-outlet diameter ratio of 0.65 and a diffuser in which the airflow path has an increasing and decreasing radius of rotation. Details of test apparatus, instrumentation, and procedure are summarized. Test results led to a modification of the vaned collector of the compressor, increasing the airflow. Equivalent impeller speeds ranged from 3,600 to 11,500 r.p.m.

Influence of Tube-Entrance Configuration on Average Heat-Transfer Coefficients and Friction Factors for Air Flowing in an Inconel Tube. Warren H. Lowdermilk and Milton D. Grele. *U.S., N.A.C.A., Research Memorandum No. E50E23*, August 23, 1951. 29 pp., illus. 4 references.

Heat-transfer investigation of air flowing through an electrically heated Inconel tube with an inner diameter of 0.402 in. Reynolds Numbers ranged from 1×10^3 to 3.75×10^5; inside wall temperatures, 660° to 2,000°R.; and heat-flux densities up to 120,000 B.t.u. per hr. per sq.ft. Both long-approach and right-angle-edge tube entrances were tested.

Investigation of the Aerodynamic and Icing Characteristics of a Recessed Fuel Cell Vent Assembly. I—Rear Wall Vent Tube Mounting. II—Ramp Floor Vent-Tube Mounting. III—NACA Flush-Inlet-Type Vent. Robert S. Ruggeri. *U.S., N.A.C.A., Research Memorandums Nos. E8A27b, E8B05a, E8C05*, March 29, 30, April 23, 1948. 24, 23, 32 pp., illus. 1 reference.

The Critical Flow of a Gas Through a Convergent Nozzle. V. D. Naylor. *Aircraft Engineering*, Vol. 23, No. 268, June, 1951, pp. 160–162, illus. Critical flow conditions for the one-dimensional case of flow in a convergent nozzle, considering internal friction and its effects.

Penetration of Liquid Jets into a High-Velocity Air Stream. Louis J. Chelko. *U.S., N.A.C.A., Research Memorandum No. E50F21*, August 14, 1950. 23 pp., illus. 2 references.

Investigation of penetration characteristics of water jets directed approximately perpendicularly to a high-velocity air stream. An analysis of the results correlated the penetration data for jet nozzles of various throat diameters, air-stream densities, and liquid-jet velocities.

Discussion on "Momentum and Mass Transfer in Coaxial Gas Jets," by W. Forstall, Jr., and A. H. Shapiro. M. Z. v. Krzywoblocki and Maurice Spielman. **Authors' Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 219, 220. Extends the bibliography of the original article with 73 items.

Discussion on "Temperature Distribution in a Steady, Laminar, Preheated Air Jet," by Chia-Shun Yih. M. Z. v. Krzywoblocki. **Author's Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 228, 229.

STABILITY & CONTROL

Practical Methods of Calculation Involved in the Experimental Study of an Autopilot and the Autopilot-Aircraft Combination. Louis H. Smaus and Elwood C. Stewart. *U.S., N.A.C.A., Technical Note No. 2373*, June, 1951. 26 pp., illus. 2 references.

Methods and formulas for handling experimental data in an autopilot-aircraft system of the position-control type characterized by feedback or angular displacement and rate of angular displacement. Equations are derived for the stability analysis of the entire system.

Rigid-Body Dynamics of Aircraft Including Non-Stationary Aerodynamics. E. V. Laitone. *Douglas Aircraft Company, Inc., Report No. SM-13820*, January 5, 1951. 58 pp., illus. 19 references.

The equations of motion as used in aircraft dynamics are analyzed to show their application and limitation. Simplified forms are developed for the longitudinal and lateral equations of motion. The Transfer Function-Fourier method gives accurate results if used with a Fourier Synthesizer. The airplane response can be obtained graphically by using the Duhamel integral.

An Investigation of the Effects of Jet-Outlet Cut-Off Angle on Thrust Direction and Body Pitching Moment. James R. Black-

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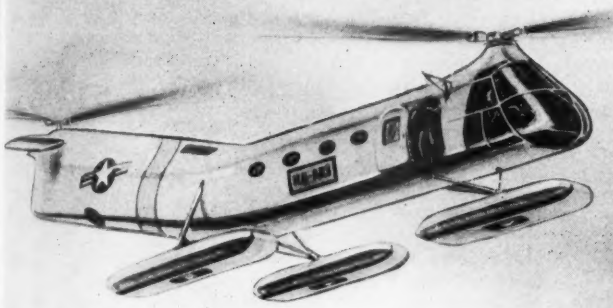

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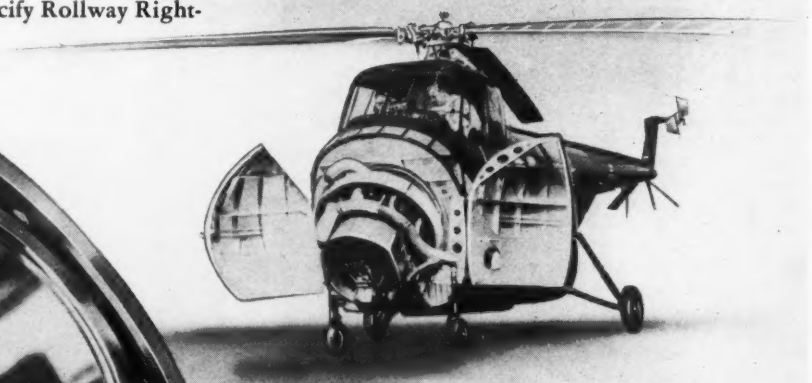

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aby. *U.S., N.A.C.A., Technical Note No. 2379*, June, 1951. 39 pp., illus. 4 references.

Wind-tunnel investigation in the Ames 7- by 10-ft. tunnel to study the effects of jet-outlet cut-off angle on the directional spreading characteristics of an unheated, subsonic air jet and on the pitching moment of a body of revolution with a jet exhaust at the tail. The jet-outlet was cut at angles of 0°, 30°, 60°, and 75°. Visual studies were also made of the jet exhausting into still air.

WINGS & AIRFOILS

Supersonic Flow Past Bodies of Revolution with Thin Wings of Small Aspect Ratio. P. M. Stocker. *Aeronautical Quarterly*, Vol. 3, Part 1, May, 1951, pp. 61–79, illus. 1 reference. Solution of these cases by operational methods.

Aeroelasticity

The Symmetric Vibrations of Aircraft. R. W. Traill-Nash. *Aeronautical Quarterly*, Vol. 3, Part 1, May, 1951, pp. 1–22, illus. 7 references.

Development of the eigenvalue equations, in matrix form and notation, using the "lumped-mass" approximation associated with a continuous elastic system. Numerical solution for a specific aircraft involves inserting the values of the physical properties in the final eigenvalue equations; matrix iteration or escalator methods can then be used. Analysis can be extended to swept- and cranked-wing aircraft.

The Principles Underlying the Dynamic Stressing of Aeroplanes. D. Williams. *Royal Aeronautical Society, Journal*, Vol. 55, No. 486, June, 1951, pp. 362–381, illus. Elementary analysis of the principles governing the behavior of structures under transient aerodynamic loads.

Matrix Method of Determining the Longitudinal-Stability Coefficients and Frequency Response of an Aircraft from Transient Flight Data. James J. Donegan and Henry A. Pearson. *U.S., N.A.C.A., Technical Note No. 2370*, June, 1951. 29 pp., illus. 10 references.

An Approach to the Buffeting Problem from Turbulence Considerations. H. W. Liepmann. *Douglas Aircraft Company, Inc., Report No. SM-13940*, March 13, 1951. 25 pp., illus. 5 references.

The response of a mechanical system to a random force is developed, and this procedure is extended to the lift forces of a two-dimensional thin airfoil moving through turbulent air. The analysis is confined to isotropic turbulence, and the response of the airfoil to a sinusoidal function (fluctuating angle of attack) and the intensity and power spectrum of the turbulence are formulated. Spanwise effects are not studied in detail. General expressions are obtained for the deflection of the wing under the lift forces and the related additional aerodynamic effects.

Investigation of Flight Flutter Testing Techniques. Martin D. Schwartz and Donald L. Wrisley. *Aeronautical Engineering Review*, Vol. 10, No. 8, August, 1951, pp. 24–34, illus. 21 references.

A survey of the literature of flight-flutter testing and an evaluation of methods and results showed the need for satisfactory and practical methods of excitation which could produce sufficient response amplitudes in the structures. Wind-tunnel tests of steady-state and pulse-methods of excitation demonstrated the practicality of these techniques for flight testing.

The Fundamentals of Flutter. W. J. Duncan. (*Aircraft Engineering*, Vol. 17, Nos. 17, 18, January, February, 1945, pp. 16–20; 32–38, 50.) *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2417*, 1951 (November, 1948). 36 pp., illus. 19 references. British Information Services, New York. $1.50.

Binary Aileron-Spring-Tab Flutter. G. A. Naylor and Anne Pellew. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2576*, 1951 (April, 1942). 11 pp., illus. 4 references. British Information Services, New York. $0.65. Calculation of the variation in flutter speed for binary aileron spring-tab flutter, assuming that both aileron and tab are rigid and that both rotate about their hinge lines.

On the Use of Coupled Modal Functions in Flutter Analysis. Donald S. Woolston and Harry L. Runyan. *U.S., N.A.C.A., Technical Note No. 2375*, June, 1951. 13 pp., illus. 7 references.

An investigation of the flutter characteristics of a uniform, unswept, cantilever wing of high aspect ratio and under conditions of high mass coupling by means of an analysis of the Rayleigh type based on coupled modal functions. The method of conducting coupled mode analysis is outlined.

Transient Loading of Wide Delta Airfoils at Supersonic Speeds. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 543–554, illus. 9 references.

The indicial admittance of a pointed wing is used to calculate the lift and rolling moments of a wide delta wing due to sudden change in angle of attack, a uniform sharp-edged gust, an impulsive gust, and impulsive antisymmetric (rolling) gusts.

Aerodynamics of a Supersonic Rectangular Wing Striking a Sharp-Edged Gust. Theodore R. Goodman. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 519–526, illus. 10 references.

Expressions are derived for the pressure by using Gardner's method of reducing a nonsteady finite-wing problem to two three-dimensional boundary-value problems. Formulas are developed by integration of the pressures for the lift and leading-edge moment.

A Superposition Method for Calculating the Aeroelastic Behavior of Swept Wings. R. B. Brown, K. F. Holtby, and H. C. Martin. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 531–542, illus. 4 references.

Development and application of the superposition method. Rigid-wing load and elastic data are tabulated for various angle-of-attack distributions. Solutions are presented for level-flight conditions and the lateral control problem for various types of loadings.

Three-Dimensional Unsteady Lift Problems in High-Speed Flight—The Triangular Wing. Harvard Lomax, Max. A. Heaslet, and Franklyn B. Fuller. *U.S., N.A.C.A., Technical Note No. 2387*, June, 1951. 62 pp., illus. 12 references.

Aerodynamic characteristics of a flat-plate triangular wing in supersonic unsteady motion. For the case of a wing with supersonic edges, the indicial lift and pitching moment coefficients are determined for boundary conditions corresponding to flat sinking and pitching wings. The coefficients are determined as functions of time. For a wing with subsonic edges, the analysis is carried out only for very narrow wings using slender wing theory.

Vibrations of a Swept Box. J. M. Radok. *College of Aeronautics, Cranfield, England, Report No. 47*, April, 1951. 13 pp., illus. 3 references. 5s.

The equations of motion are developed for a uniform swept box that is reinforced by ribs and stringers in terms of the vertical displacement and twists about two oblique axes. The boundary conditions at the free end of a cantilever are used to transform the equations into integral equations, assuming normal vibrations and the absence of additional masses. The resulting equations are solved by an approximate method.

Torsion and Transverse Bending of Cantilever Plates. Eric Reissner and Manuel Stein. *U.S., N.A.C.A., Technical Note No. 2369*, June, 1951. 39 pp., illus. 2 references.

Development of a simplified plate theory applicable to thin cantilever wings of arbitrary shape and thickness variation subjected to arbitrary loading. The theory assumes linear deformations in the chordwise direction and uses the minimum-potential energy principle. Taper and sweep are considered in applying the procedure to static-deflection problems.

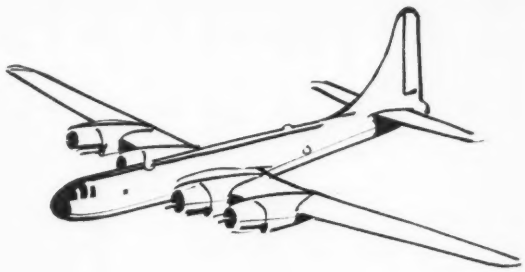
Vibration of Rectangular and Skew Cantilever Plates. M. V. Barton. *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 129–134, illus. 13 references.

Study of the frequencies and modes of vibrations of homogeneous elastic cantilever plates of uniform thickness using the Ritz method. Rectangular cantilever plates with span-to-breadth ratios of $^1/_2$, 2, and 5, and skew cantilever plates with sides of equal length and skew angles of 15°, 30°, and 45° are analyzed.

Discussion on "Vibration of Rectangular Plates by the Ritz Method," by Dana Young. J. N. Goodier, K. T. Chang, and A. Weinstein. **Author's Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, p. 229.

Discussion on "Matrix Solution for the Vibration of Nonuniform Beams," by W. T. Thompson. H. W. Pope, R. M. Rosenberg, and E. H. Bateman. **Author's Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 227, 228. 3 references.

Discussion on "Natural Frequencies of Continuous Beams of Uniform Length," by R. S. Ayre and L. S. Jacobsen. E. D'Appolonia, L. E. Goodman, and J. G. Sutherland. **Authors' Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 217, 218, illus. 6 references.



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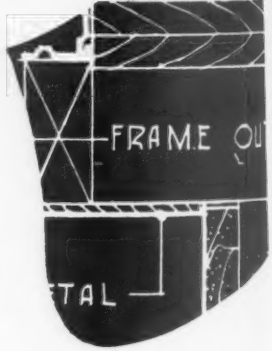

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Discussion on "Beam Vibrations with Time-Dependent Boundary Conditions," by R. D. Mindlin and L. E. Goodman. E. H. Lee, W. H. Hoppmann, 2nd, N. O. Myklestad, and G. A. Nothmann. *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 224–226, illus. 3 references.

Readers' Forum: Effective End Restraint of Columns by Frequency Measurements. Harold Lurie. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 566, 567. 3 references.

Free Vibrations of a Pin-Ended Column with Constant Distance Between Pin Ends. David Burgreen. *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 135–139, illus. 2 references.

Analysis of a pin-ended column that vibrates with constant frequency between its pin ends. An exact solution of the nonlinear differential equation of the system is obtained in terms of elliptic functions. It is determined that the frequency depends upon the amplitude of vibration; amplitude effects increase as the Euler load is approached. Test procedure and apparatus are described; experimental data are compared with theory.

Air Transportation (41)

Future Air Transport Possibilities. Grover Loening. *Aeronautical Engineering Review*, Vol. 10, No. 8, August, 1951, pp. 17–23, illus. Review of air-transport progress; general trends of future development; major problems.

Problems Affecting Air Cargo Development in California. II. Harry E. Karst. *Air Transportation*, Vol. 18, No. 4, April, 1951, pp. 9, 28–31, illus. Results of a study of air-freight and air-cargo shipments to and from California; ground handling and terminal facilities.

United States Overseas Air Cargo Services. XIII, XV. N. W Kendall. *Air Transportation*, Vol. 18, Nos. 4, 6, April, June, 1951, pp. 10, 31–34; 10, 28, 29.

Flight Planning and Direct-Operating Costs. Armin Baltensweiler. *Interavia*, Vol. 6, No. 5, May, 1951, pp. 271–274, illus.

Study of the influence of engine power, altitude, and wind force on direct operating costs of present-day piston-engined long-range transport aircraft. Results are presented in charts that show the variation in operating costs and factors with engine output, altitude, and wind force.

Economic and Managerial Factors Underlying Subsidy Needs of Domestic Trunk Line Air Carriers. Harold D. Koontz. *Journal of Air Law and Commerce*, Vol. 18, No. 2, Spring, 1951, pp. 127–156, illus., tables. 2 references.

A Critique of Proposals to Separate Subsidy from Air Mail Pay. D. Philip Locklin. *Journal of Air Law and Commerce*, Vol. 18, No. 2, Spring, 1951, pp. 166–180. 11 references.

Report of Ernst & Ernst on Survey of Separation of Compensatory Mail Pay from Total Mail Payments to Domestic Airlines. *Journal of Air Law and Commerce*, Vol. 18, No. 2, Spring, 1951, pp. 206–233. 2 references.

Discussion of "Some Economic Factors in Air Transport Operation," by Peter Masefield. G. E. Woods-Humphery. **Author's Reply.** *The Aeroplane*, Vol. 80, Nos. 2069, 2078, 2079, March 16, May 18, 25, 1951, pp. 330–333; 610–612; 637–640.

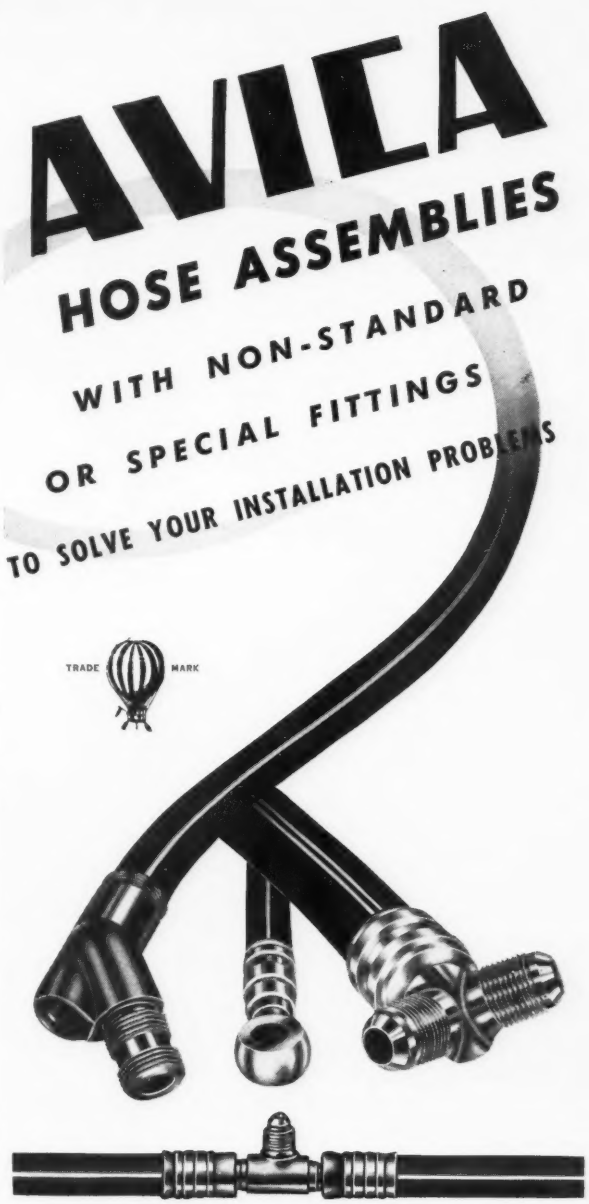
Airline Passenger Traffic Pattern Within the United States. D'Arcy Harvey. *Journal of Air Law and Commerce*, Vol. 18, No. 2, Spring, 1951, pp. 157–165, illus. Factors determining air-line passenger traffic pattern based on C.A.B. Airline Traffic Survey data of September, 1948.

Airplane Design (10)

The Rocket-Powered Interceptor; A Brief History to Date. *Flight*, Vol. 59, No. 2210, June 1, 1951, pp. 645–648, illus.

An Investigation into the Suitability of Proposed Aircraft Design Memoranda Tests for Deck-Landing Aircraft. I—Seafire IIc and Barracuda II. Appendix. II—Helcat I and Avenger I. D. Lean and J. R. Stott. P. A. Hufton. D. Lean, D. Johnson, and J. R. Stott. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2407*, 1951 (October, 1947). 55 pp., illus. 10 references. British Information Services, New York. $2.40.

Transit Van—Universal Cargo Container. William D. Perreault. *American Aviation*, Vol. 15, No. 2, June 11, 1951, pp. 14–16, illus.



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El Avión de Turismo. Felipe Ulberich. *Revista Nacional de Aeronáutica*, Vol. 11, No. 108, March, 1951, pp. 32, 33, illus. In Spanish. Suggested performance and characteristics of an ideal light plane.

AIRPLANE DESCRIPTIONS

First Details of U.S. Jet Transport Plans. *Aviation Week*, Vol. 54, No. 25, June 18, 1951, pp. 19, 21, 23, 24, illus.

Design specifications of the Boeing 473 four-jet sweptback-wing transport that is similar to the six-jet B-47 and will carry 60–97 passengers, and the Lockheed L-193 four-jet sweptback-wing transport that is a scaled-up version of the F-90, for 48–64 passengers.

de Havilland D.H. 106 Comet Four-Engined Turbojet Transport, England. I, II. H. Povey. *Aircraft Production*, Vol. 13, Nos. 151, 152, May, June, 1951, pp. 134–141; 170–178, illus., cutaway drawings.

Design and production liaison, fuselage tooling and construction; construction and tooling of the wing, plaster models, glass-cloth molding.

de Havilland D.H. 114 Heron 14-Passenger Four-Engined Transport Airplane, England. *The Aeroplane*, Vol. 80, No. 2078, May 18, 1951, pp. 601–607, illus., cutaway drawing.

Fokker S.13 Twin-Engined Trainer Airplane, Netherlands. *Flight*, Vol. 59, No. 2209, May 25, 1951, pp. 608–609, 611, illus.

Gloster Meteor F.Mk.8 Twin-Engined Turbojet Interceptor Fighter Aircraft, England. *The Aeroplane*, Vol. 80, No. 2081, June 8, 1951, pp. 685–691, illus., cutaway drawing.

HA-43 450-Hp. Two-Place Low-Wing Trainer, Spain. *Avión*, Vol. 6, No. 62, April, 1951, pp. 183, 184, illus. In Spanish.

Hawker P.1052 Single-Engined Turbojet Fighter Airplane, England. *Aviation Week*, Vol. 45, No. 24, June 11, 1951, p. 34, cutaway drawing.

Lockheed Constellation Four-Engined Transport Aircraft. *Aero Digest*, Vol. 62, No. 6, June, 1951, pp. 26–29, 44–46, 52, illus. Development history. *Aviation Age*, Vol. 15, No. 6, June, 1951, pp. 32, 33, illus.

Lockheed F-94 Single-Engined Turbojet Fighter Aircraft. *Aviation Week*, Vol. 54, No. 26, June 25, 1951, pp. 20–23, illus.

Lockheed XR60-1 Constitution 4-Engined Transport. W. M. Hawkins, Jr., and R. L. Thoren. *SAE Journal*, Vol. 59, No. 6, June, 1951, pp. 47–54, illus. (Excerpts from a paper: Lockheed Constitution Development Story.)

Max Holste M.H. 152 Single-Engined (240-Hp.) 5-Place Multi-Purpose Airplane, France. *L'Aviation Marchande*, No. 39, March, 1951, pp. 17–20, illus. In French.

Morane Saulnier M.S. 700–703 Petrel Twin-Engined Multiple-Purpose 4-Place Airplanes, France. R. Gauthier. *Congrès Aéronautique de l'Union Française, May 3–12, 1950, Preprint.* 23 pp., illus. In French.

Morane-Saulnier M.S. 732–733 Single-Engined 3-Place Primary Trainers, France. *Avions Morane-Saulnier*, July, 1950. 17 pp., illus., folding chart. In French.

S.A.N.-101 Two-Place Single-Engined High-Wing Light Airplane, France. *Les Ailes*, Vol. 31, No. 1313, March 31, 1951, pp. 8, 9, illus. In French.

EJECTION SEATS

A Hasty Exit. *Aircraft*, Vol. 13, No. 6, June, 1951, pp. 12, 14, 15, illus. Design and operation of the Martin-Baker ejection seat.

LANDING GEAR

Breaking Skids Betters Braking. Thomas L. Self. *Aviation Week*, Vol. 54, No. 23, June 4, 1951, pp. 49, 50, 53, illus. Components and operation of the Hytrol antiskid braking system, developed by Boeing Airplane Co. and manufactured by Hydro-Aire, Inc.

New Anti-Skid Device Cuts Tire Damage; Hytrol System. *American Aviation*, Vol. 15, No. 4, June 25, 1951, pp. 25, 26, illus.

WINDSHIELDS

Fighter Canopy; Manufacture of Double-Skinned Unit for the Vickers-Supermarine Attacker. *Aircraft Production*, Vol. 13, No. 152, June, 1951, pp. 180–184, illus. The windshield and canopy incorporate two molded acrylic panels with an interspace open to cockpit pressure.

Airports & Airways (39)

Approach Light Systems Re-Examined; CAA-Sponsored Tests by AF, Navy, and ALPA Expected to Result in New International Standard. William D. Perreault. *American Aviation*, Vol. 15, No. 4, June 25, 1951, pp. 20, 23, 24, illus.

Aviation Medicine (19)

Medical Problems of Military Aviation. Edward J. Kendricks. *Military Surgeon*, Vol. 108, No. 6, June, 1951, pp. 467–481. 15 references.

Education & Training (38)

A Landing Display for Use with a Contact Flight Simulator (Human Engineering Systems Studies). John M. Bell. (Illinois, University, Department of Psychology.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 71-16-8*, March, 1951. 14 pp., illus. 1 reference.

New Radar Trainers for USAF. *Aviation Week*, Vol. 54, No. 25, June 18, 1951, pp. 57–59, illus. Method of operation of the Transducer Corp. AN/APG-T1 gun-laying radar trainer for tail gunners, and AN/APQ-T2 navigational-bombing trainer.

Electronics (3)

Standards on Pulses: Definitions of Terms. I—*1951* (Standard *51* IRE *20* S *1*). *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 624–626.

Impedance and the Laplace Transform. Edward E. Ward. *Wireless Engineer*, Vol. 28, No. 333, June, 1951, pp. 192–194, illus.

ANTENNAS

A Very-High-Frequency–Ultra-High-Frequency Tail-Cap Antenna. Louis E. Raburn. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 656–659, illus. 11 references.

Development of a zero-drag vertically polarized omnidirectional antenna for use with V.H.F. and U.H.F. radio equipment on single-engined aircraft. The antenna consists of a vertical stabilizer, tip-fed by a metal tail cap; frequency range is 100–400 mc.

The Patterns of Antennas Located Near Cylinders of Elliptical Cross Section. George Sinclair. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 660–668, illus. 12 references.

The patterns of loop and dipole antennas are determined by a method based on diffraction theory and the reciprocating theorem. The method involves calculating the open-circuit terminal voltages of the antennas when receiving plane waves. The problem reduces to the diffraction of a plane wave around an elliptic cylinder, for which expressions are developed. Calculation procedure and factors for antennas on elliptic and circular cylinders are tabulated.

Current Distributions on Helical Antennas. James A. Marsh. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 668–675, illus. 13 references.

Measurement of current distributions over a frequency range of 600–1,700 mc. to study the current distribution as a function of distance along the helix and as a function of frequency. The antenna measured is a six-turn helix with a pitch angle of 12.6° and a mean diameter of 8.61 cm. The data are analyzed in terms of traveling waves associated with three modes of transmission on the helix. An approximation is obtained for the phase velocities of the traveling waves, from which the far-field radiation pattern of the helix can be determined.

Horizontally-Polarized Omnidirectional Antenna. Charles Brasse, Jr., and Richard Thomas. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 86, 87, illus.

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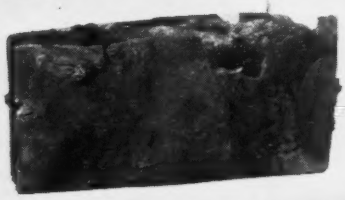

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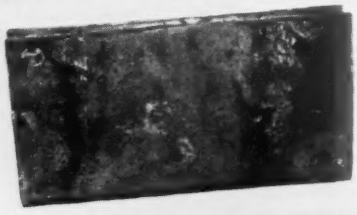

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Dielectric Aerials with Shaped Radiation Patterns. D. G. Kiely. *Wireless Engineer*, Vol. 28, No. 333, June, 1951, pp. 177–178, illus. 2 references. An empirical method of designing an antenna for 3.2 cm. with a magnetic-plane bandwidth of 240° to 6-db. points, which uses the properties of dielectric-rod antennas.

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The Cascaded Binary Counter with Feedback. G. Franklin Montgomery. *Journal of Applied Physics*, Vol. 22, No. 6, June, 1951, pp. 780–782, illus. 5 references.

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Square-Wave Generator; Practical Design Giving Three Repetition Frequencies at Low Impedance. O. C. Wells. *Wireless World*, Vol. 57, No. 1, January, 1951, pp. 35, illus.

Square-Wave Generator Using Gated-Beam Tube. Louis E. Garner, Jr. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 128, 129, illus. 1 reference.

Circuit description and design features of a square-wave generator that provides five frequencies of operation ranging from 50 to 500,000 pulses per sec. Output (cathode follower) impedance varies from 50 to 550 ohms. The instrument can be used for checking frequency response, phase shift, or transient response.

Constant-Amplitude Oscillator. Norris C. Hekimian. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 164, 166, 168, 171, illus.

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Use of an a.c. power supply for the strain-gage bridge for measuring low strains and dynamic loading. The carrier system has three major components—a.c. power supply, bridge circuit and balancing network, and an amplifier-demodulator. Apparatus and procedure for balancing and checking the instrument are explained. Schematic diagrams show the power supply and strain-gage amplifier.

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The values of the equivalent circuit elements of several flexural vibrating piezoelectric crystals, slabs, and double-T-shaped plates and double strips are calculated from the effective stiffness and mass and the electromechanical coupling.

Transistor Frequency Modulator Circuit. L. L. Koros and R. F. Schwartz. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 130–132, 134, illus. 2 references. Circuit details; experimental results.

The Design of Thermistor Thermometers with Linear Calibration. W. R. Beakley. *Journal of Scientific Instruments*, Vol. 28, No. 6, June, 1951, pp. 176–179, illus. 2 references.

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Your Next Switch Selection Problem. A. L. Riche. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 162–167, illus.

Review of the principal factors affecting selection and application of precision snap-acting switches; operation, life expectancy, vibration and impact resistance, electrical capacity of switches; mercury switches. The mechanical and electrical characteristics of typical switches are tabulated; drawings show 37 applications.

Speed-Controlled Switch. H. W. Kretsch and F. J. Walker. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 112, 113, illus.

Speed control with an a.c. tachometer. The tachometer output frequency is used as input to a frequency-sensitive network; the speed switch operates a relay at a preselected speed. The apparatus can be used to operate auxiliary equipment at a specific speed setting.

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Relaxation Methods Applied to the Problem of A.C. Magnetization of Ferromagnetic Laminae. O. I. Butler and M. R. Sarma. (*I.E.E., Measurements Section, Paper No. 1026.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 63, June, 1951, pp. 389–398, illus. 13 references.

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Circuit Printers for Flat and Cylindrical Surfaces. *U.S., National Bureau of Standards, Technical Report No. 1548*, June, 1951. 5 pp. 5 references. Semiautomatic machines.

Printed Electronic Circuits. *Aerovox Research Worker*, Vol. 21, No. 4, April, 1951, pp. 1–3, illus. Types, relative advantages, and repairs.

Auto-Sembly of Miniature Military Equipment. S. F. Danko and S. J. Lanzalotti. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 94–98, illus.

Basic concepts and techniques. Printed circuits are acid-etched on copper-foil-coated insulating laminates. Holes for leads of components are punched or drilled, and leads are inserted. The chassis underside is immersed in an eutectic solder bath (at 450°F.) for a period of about 1–3 sec.

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Development and construction features of a 12-tube subminiature radio receiver that is $^1/_5$ the size of a similar receiver used in World War II. The receiver, which occupies 55 cu.in., has an intermediate frequency of 130 kc., continuous tuning from 190–550 kc., a sensitivity of 5 microvolts for 6 db. signal-to-noise ratio, and a power output of 100 mw.

Production Planning Speeds Military Orders. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 82–85, illus. Details of the Sperry Gyroscope Co. program.

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The Selective Electrostatic Storage Tube. Jan Rajchman. *RCA Review*, Vol. 12, No. 1, March, 1951, pp. 53–97, illus. 12 references.

Switch and Storage Tubes; Some Experimental Types. L. S. Allard and R. T. Hill. *Wireless Engineer*, Vol. 28, No. 333, June, 1951, pp. 187–191, illus. 2 references.

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Grid Current and Grid Emission Studies in Thyratrons—the Trigger-Grid Thyratron. L. Malter and M. R. Boyd. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 636–643, illus. 3 references.

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Application of conductance curves (lines along which the values of the transconductance and plate conductance are constant) to circuit design involving pentode and triode tubes. Use of the curves is illustrated by the technique for triode tubes.

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Condenser Microphone Sensitivity Measurement by Reactance Tube Null Method. H. E. von Gierke and W.-W. von Wittern. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 633–635, illus. 5 references.

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Frequency Analysis by Electronic Analog Methods. W. A. McCool. *U.S., Naval Research Laboratory, Washington, Report No. 3724*, August 21, 1950. 12 pp., illus. 4 references.

Theory of an electronic-analog computing technique that reduces the evaluation of direct Fourier transforms to solving an ordinary differential equation of the second order. The procedure is extended to the evaluation of inverse transforms. The manner in which the electronic-analog technique is used to mechanize and solve the differential equations of the inverse transform is explained.

Millimicrosecond Oscillography. Y. P. Yu, H. E. Kallman, and P. S. Christaldi. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 106–111, illus. 12 references. Development of distributed amplifiers for measurement of pulses of 0.5 millimicrosecond.

Sensitive Null Detector; Selective A.F. Bridge Amplifier Giving Visual and Aural Indication of Amplitude Variation over 10 μV to 10 *V* Range Without Manual Gain Adjustment. M. G. Scroggie. *Wireless World*, Vol. 57, No. 5, May, 1951, pp. 175–178, illus.

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Operating principles of an instrument for direct indication of imaginary and real components of an unknown voltage in terms of a reference voltage over a frequency range of 8 cycles to 500 mc.; measurement of the phase angle between two given voltages; measurement of complex components in an unknown voltage; applications.

Test Generator for Pulse Coded Systems. De Witt H. Pickens and Albert A. Gerlach. *Radio & Televisiom News*, Vol. 46, No. 1, July, 1951, *Radio-Electronic Engineering*, pp. 14, 15, illus. 1 reference.

Operation of a test generator, developed by the Naval Research Laboratories, which is used to align and test decoding equipment for pulse-width-coded systems. A circuit diagram shows component values.

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Design and applications of the General Radio Company U.H.F. Admittance Meter that measures the conductive and susceptive component of an unknown circuit. Impedance is read directly from dials after balancing the instrument to a null.

Sub Smasher . . . One of the most completely electronically equipped planes ever built, the U. S. Navy's new Martin P5M-1 Marlin is a deadly anti-submarine weapon designed to detect surfaced and snorkeling submarines. And, once the sub has been located, the Marlin carries the killing punch in its bomb bays to destroy the enemy raider.

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NAVIGATION AIDS

Description and Evaluation of 100-Channel Distance-Measuring Equipment. R. C. Borden, C. C. Trout, and E. C. Williams. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 612–618, illus. 9 references. History and development; modifications necessary to expand the 50-channel D.M.E. equipment to the 100-channel system.

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NOISE & INTERFERENCE

Interference in Multi-Channel Circuits. L. Lewin. (*Wireless Engineer*, Vol. 27, No. 327, December, 1950, pp. 294–304.) *Electrical Communication*, Vol. 28, No. 2, June, 1951, pp. 142–155, illus. 3 references.

Investigation of distortion due to mismatches on a long feeder line by a method involving the determination of second and third harmonics and the setting up of the direct relation between the harmonics and interference. The importance of slight variations of feeder length or carrier frequency is stressed.

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Optimum Operation of Echo Boxes. W. M. Hall and W. L. Pritchard. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 680–684, illus. 6 references.

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The Use of Saturable Reactors As Discharge Devices for Pulse Generators. W. S. Melville. (*I.E.E., Radio Section, Paper No. 1034.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 53, May, 1951, pp. 185–204, Discussion, pp. 204–206, illus. 8 references.

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Single-Conductor Surface-Wave Transmission Lines. Georg Goubau. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 619–624, illus. 8 references.

A Variable-Length Radio-Frequency Transmission-Line Section. K. R. McAlister. *Journal of Scientific Instruments*, Vol. 28, No. 5, May, 1951, pp. 142, 143, illus. For ultra-high frequencies; uniform characteristic impedance is preserved throughout its length.

Corrugated-Waveguide Band-Pass Filters. J. C. Greene. *Electronics*, Vol. 24, No. 7, July, 1951, pp. 117–119, illus. 8 references.

Design procedure and filter characteristics of a tapered corrugated surface that forms one face of the waveguide. The filter has a pass-band between 2,080 and 2,800 mc. and 70-db. attenuation, relative to the pass-band response, at 2,900 mc. The pass-band loss in the filter was approximately 2.5 db.

A Waveguide Rotary Joint with Waveguide Feed. Louis D. Breetz. *U.S., Naval Research Laboratory, Washington, Report No. 3795*, January 18, 1951. 13 pp., illus.

Cylindrical Wave Guides. *Radio & Television News*, Vol. 46, No. 1, July, 1951, *Radio-Electronic Engineering*, p. 32, illus. Nomograph for determining ratio of guide wavelength to free-space wave length in cylindrical wave guides.

On the Representation of the Electric and Magnetic Fields Produced by Currents and Discontinuities in Wave Guides. I. N. Marcuvitz and J. Schwinger. *Journal of Applied Physics*, Vol. 22, No. 6, June, 1951, pp. 806–819, illus. 2 references.

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A Study of Tropospheric Scattering of Radio Waves. A. W. Straiton, D. F. Metcalf, and C. W. Tolbert. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 6, June, 1951, pp. 643–648, illus. 5 references.

Comparison of Ionospheric Radio Transmission Forecasts with Practical Results. A. F. Wilkins and C. M. Minnis. (*I.E.E., Radio Section, Paper No. 1101.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 53, May, 1951, pp. 209–220, illus. 3 references.

On the Nonspecular Reflection of Electromagnetic Waves. Victor Twersky. *Journal of Applied Physics*, Vol. 22, No. 6, June, 1951, pp. 825–835, illus. 7 references.

The Ionospheric Propagation of Low- and Very Low-Frequency Radio Waves Over Distances Less Than 1,000 Km. R. N. Bracewell, K. G. Budden, J. A. Ratcliffe, T. W. Straker, and K. Weekes. (*I.E.E., Radio Section, Paper No. 1123.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 53, May, 1951, pp. 221–236, illus. 54 references.

Radio in the Jungle; Propagation Through Dense Vegetation and Humid Atmosphere. *Wireless World*, Vol. 57, No. 2, February, 1951, pp. 73, 74, illus.

Equipment

ELECTRIC (16)

Electrical Connectors for Equipment Power and Control Circuits. Application Engineering Staff, Scintilla Magneto Division, Bendix Aviation Corp. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 117–119, illus. Electric and mechanical requirements to be considered in selecting precision electric connectors; military specifications.

HYDRAULIC & PNEUMATIC (20)

Constant Speed for Airborne Generators. George L. Christian. *Aviation Week*, Vol. 52, No. 25, June 25, 1951, pp. 48–50, illus.

Sunstrand Machine Tool Co. development of engine-driven, hydraulic, constant-speed accessory drive pads for jet engines. A cartridge-type hydraulic constant-speed drive using a synthetic hydraulic fluid is incorporated into the jet engine.

Sequential Operation of Hydraulic Cylinders. H. L. Stewart. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 160, 161, illus.

Drawings show the positions of the components in the following operational phases: pressure-operated sequence valve, cam-operated sequence valve, manual control at constant pressure in which one cylinder of a group can be operated without causing an appreciable pressure drop in the other cylinders, moving different loads in sequence, electric control, rotary motion, and operation of a reciprocating piston.

Synthetic Rubber O-Ring Seals. E. L. Carlotta. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 130–135, illus.

Sealing of static or moving parts in hydraulic systems with O-rings. Properties and major applications of natural and synthetic rubber O-ring materials are tabulated and evaluated. Cutaway drawings show O-ring design and installation.

Transient Phenomena in a Damped-Vibration System with Non-Linear Characteristics. III. Hidelo Fukuka. *Japan Society for Applied Mechanics, Journal*, Vol. 4, No. 21, January, 1951, pp. 1–3, illus. 2 references. In Japanese; English summary. Analysis of nonlinear problems of hydraulic damping systems by means of the Laplace transformation.

All Big DC-6 Fleets Go to Skydrol. George L. Christian. *Aviation Week*, Vol. 54, No. 25, June 18, 1951, pp. 65, 66, 69, 70, illus. Physical and chemical properties of Douglas-Monsanto Skydrol fire-resistant, chemically stable hydraulic fluid.

Air Motor. *Aircraft Production*, Vol. 13, No. 152, June, 1951, pp. 165, 166, illus., cutaway drawings.

Design and production procedure of an experimental model of a small Roots-type air-motor for the operation and control of aircraft auxiliary equipment. The motor, developed by the Wade Engineering Co., Ltd., is essentially a four-lobed supercharger that operates on a comparatively low air pressure.

EEMCO technical bulletin

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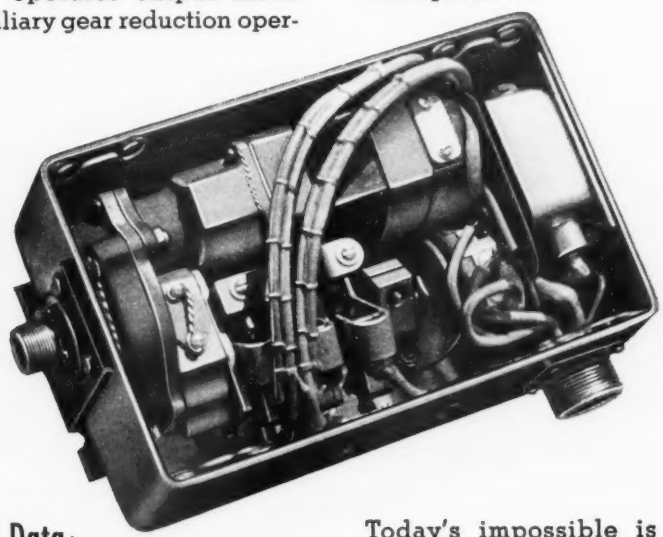
This entirely self-contained rotary actuator package designed and built by EEMCO, combines compactness, high performance, and light weight.

Totally enclosed in a metal box equipped with mounting bracket, it incorporates motor, magnetic clutch and spring-loaded brake. Main gear reduction operates output drive shaft...auxiliary gear reduction operates three adjustable limit switches — two for limiting travel, one for neutral position indication light. Auxiliary reduction also drives potentiometer for position indication.

The unit provides continuous elevator correction on one of the latest jet fighters through the automatic pilot.



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Operates in ambient temperature of 250° F.

Output r. p. m. 2500 at 3 inch-pound load. Weight complete — 3¼ pounds.

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Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

Indication, Measurement and Control of Ice Accretion. D. F. Lucking. *Royal Aeronautical Society, Journal*, Vol. 55, No. 486, June, 1951, pp. 382–385. 4 references. Design and operation of ice-accretion meters.

Investigation of the Aerodynamic and Icing Characteristics of a Recessed Fuel Cell Vent Assembly. I—Rear Wall Vent Tube Mounting. II—Ramp Floor Vent-Tube Mounting. III—NACA Flush-Inlet-Type Vent. Robert S. Ruggeri. *U.S., N.A.C.A., Research Memorandums Nos. E8A27b, E8B05a, E8C05*, March 29, 30, April 23, 1948. 24, 23, 32 pp., illus. 1 reference.

Flight Safety & Rescue (15)

Experimental U.S. Air Force Fire Trucks. *National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletin No. 63*, April, 1951. 4 pp., illus.

A Hasty Exit. *Aircraft*, Vol. 13, No. 6, June, 1951, pp. 12, 14, 15, illus. Design and operation of the Martin-Baker ejection seat.

Flight Testing (13)

Investigation of Flight Flutter Testing Techniques. Martin D. Schwartz and Donald L. Wrisley. *Aeronautical Engineering Review*, Vol. 10, No. 8, August, 1951, pp. 24–34, illus. 21 references. Survey of past work on in-flight flutter test techniques; major problems; wind-tunnel and in-flight experiments with improved techniques; accuracy of results.

Fuels & Lubricants (12)

Antiknock Evaluation of Hydrocarbons and Ethers As Aviation Fuel Components. Henry C. Barnett. *U.S., N.A.C.A., Research Memorandum No. E50H02*, October 5, 1950. 132 pp., illus. 24 references. Antiknock data on 18 branched paraffins and olefins, 27 aromatics, and 22 ethers.

Spontaneous Ignition Temperatures of Pure Hydrocarbons and Commercial Fluids. Joseph L. Jackson. *U.S., N.A.C.A., Research Memorandum No. E50J10*, December 20, 1950. 16 pp., illus. 6 references.

Synthesis of Cyclopropane Hydrocarbons from Methylcyclopropyl Ketone. III—2-Cyclopropyl-1-Butene, Cis and Trans 2-Cyclopropyl-2-Butene, and 2-Cyclopropylbutane. Vernon A. Slabey and Paul H. Wise. *U.S., N.A.C.A., Technical Note No. 2398*, June, 1951. 22 pp., illus. 10 references.

Fundamental Flame Velocities of Pure Hydrocarbons. II—Alkadienes. Oscar Levine, Edgar L. Wong, and Melvin Gerstein. *U.S., N.A.C.A., Research Memorandum No. E50H25*, November 3, 1950. 13 pp., illus. 1 reference.

The Ring Method of Measuring Surface Tension for Liquids of High Density and Low Surface Tension. H. W. Fox and C. H. Chrisman, Jr. *U.S., Naval Research Laboratory, Washington, Report No. 3793*, January 17, 1951. 10 pp., illus. 7 references.

Tables of correction factors used in the measurement of surface tension by the ring method are extended to cover the fluorocarbons and their derivatives by fitting a combined hyperbolic and linear equation to the curves derived from the Harkins and Jordan tables. The correction factor depends on R^3/V and R/r where R = ring radius, r = radius of wire of the ring, and V = maximum volume of liquid lifted above the plane of the liquid surface. The extrapolated values were verified experimentally.

Rocket Propellant Performance and Energy of the Chemical Bond. P. F. Winternitz and P. Horvitz. *American Rocket Society, Journal*, No. 85, June, 1951, pp. 51–67, illus. 4 references.

The evaluation of the exhaust temperature of a rocket motor involves knowledge of the heat of combustion. A theoretical computation of the heat of combustion of any fuel can be obtained from known values of the energy of chemical bonds in the fuel; it can be computed from the heat of combustion of the elements in the fuel. The nature of the chemical bond and the determination of the nature is reviewed. Formulas are developed for calculating the heats of combustion.

Measurement of the Burning Rate of Liquid Propellants. C. W. Tait, A. G. Whittaker, and H. Williams. *American Rocket Society, Journal*, No. 85, June, 1951, pp. 83–88, illus. 2 references.

Crawford's technique for obtaining the burning rate of solid propellants is adapted to measure the burning rate of liquid bipropellants of the nonhypergol type. Pyrex glass tubes 7 mm. in diameter were used to hold the fuel. Measurements were made with mixtures of 2-nitropropane and nitric acid.

Gliders (35)

The A.M.11 "Albatross." Leo Follman. *Sailplane and Glider*, Vol. 19, No. 6, June, 1951, pp. 129–130, illus.

The LG-124 "Galánka" Glider. R. A. G. Stuart. *Sailplane and Glider*, Vol. 19, No. 6, June, 1951, pp. 126, 138, illus.

Schwerpunktfesselung. I—Entwicklungsgeschichte. Herbert Bergk. **II—Grundsatzliches.** Josef Matschego. **III—Fliegerische Praxis.** Josef Matschego. *Thermik*, Vol. 2, Nos. 1, 2, 3, January, February, March, 1949, pp. 14–16; 35–37; 52–56, illus. In German. Center-of-gravity tow-cable attachment: development, principles, and operation.

Guided Missiles (1)

Evolution of the Guided Missile. II—U.S. Air-to-Air Experiments; Homing Systems; Rocket Interceptors. Kenneth W. Gatland. *Flight*, Vol. 59, No. 2208, May 18, 1951, pp. 598–600, illus.

Charge Densities in the Ionosphere from Radio Doppler Data. Warren W. Berning. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 175–181, illus. 6 references.

Development of a method of approximating a true trajectory of a missile, so that errors introduced in the DOVAP system can be used to measure ionization densities of the air; experience with V-2 rockets.

Instruments (9)

Automatic Control Systems Satisfying Certain General Criterions on Transient Behavior. Aaron S. Boksenbom and Richard Hood. *U.S., N.A.C.A., Technical Note No. 2378*, June, 1951. 45 pp., illus. 6 references.

Development of a general procedure of control synthesis which gives a set of equations, based on physically realizable criteria, for the optimum control systems. The methods apply the calculus of variations to minimize certain time integrals.

The Effect of Friction on the Behavior of Servo Mechanisms at Creep Speeds. J. G. L. Michel and A. Porter. (*I.E.E., Measurements Section, Paper No. 1033.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 63, June, 1951, pp. 297–308, Discussion, pp. 308–311, illus. 8 references.

Investigation of the effects of static and coulomb friction on the minimum smooth-running speed of a position-control system by a topological method and by using a differential analyzer. The topological method applies only to simple dynamic systems in which the order of the equations of motion is not above the second. The second methods gives quantitative results for a particular system and is applied to the behavior of automatic-tracking radar.

Electromagnetic Brakes for D-C Servo Motors. Gerald Kronacher. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 172–175, illus.

A formula is presented for the calculation of the coasting angle of an electromagnetic brake. The formula is an aid to the evaluation of factors affecting brake performance. Methods of minimizing the coasting angle are explained.

Practical Methods of Calculation Involved in the Experimental Study of an Autopilot and the Autopilot-Aircraft Combination. Louis H. Smaus and Elwood C. Stewart. *U.S., N.A.C.A., Technical Note No. 2373*, June, 1951. 26 pp., illus. 2 references.

Analytic methods and formulas for handling aircraft-autopilot experimental data are derived from basic autopilot theory. The system studied is of the position-control type characterized by feedback of angular displacement and rate of angular displacement. Equations are derived for obtaining the response of the closed-loop system and extended to obtain the response of the open-loop system.

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The mechanical strength of "D" Nickel, both at normal and at elevated temperatures, is greater than that of nickel. It more nearly approximates that of Monel. "D" Nickel frequently is used in applications where nickel might serve the purpose, both to guard against the possible presence of sulfur and because of its superior mechanical properties.

"D" Nickel is used chiefly in the forms of rod, wire, tubing and strip. It is used extensively for spark plug electrodes, ignition tubes and for boiler refractory bolts, particularly in marine boilers.

Low Carbon Nickel is used instead of nickel for long-time service in the temperature range 700-1200°F.

It is used in the production and handling of molten caustic soda and caustic potash and in the handling of some other molten salts, where no sulfur compounds are present.

Low Carbon Nickel is also used in the manufacture of nickel crucibles and combustion dishes for laboratory use. Such articles must be capable of withstanding oxidizing furnace atmospheres, at temperatures up to 2000°F., without spalling or loss of ability to retain their shape. In the laboratory determination of the carbon content of steel, the sample must be retained in a vessel that resists the extremely high temperatures used in the oxidation of the steel; in addition these vessels must contain no carbon to introduce errors into the test.

Low Carbon Nickel is softer than nickel and does not work-harden as rapidly. Therefore, it is often used for spinning and for coining operations. The mechanical properties are lower than corresponding forms of nickel. This applies particularly to the yield strength and elastic limit of annealed material. The ductility is somewhat greater than that of nickel. It is produced chiefly in the forms of cold-rolled sheet or strip.

For technical help on specific metal problems, write, outlining in detail, to Inco's Technical Service Section.

Chemical Composition, Mechanical Properties and Physical Constants

MATERIAL	FORM AND CONDITION	AVERAGE MECHANICAL PROPERTIES				AVERAGE PHYSICAL CONSTANTS								
		YIELD STRENGTH (0.2% offset) 1000 psi.	TENSILE STRENGTH 1000 psi.	Elongation in 2 in., per cent	HARDNESS BRINELL	DENSITY lb./cu. in.	SPECIFIC GRAVITY	MELTING POINT °F.	Specific Heat (32°-212°F.) Btu./lb./°F.	Thermal Expansion Coefficient (32°-212°F.) 10^6 in./in./°F.	Thermal Conductivity (32°-212°F.) Btu./sq. ft./hr./°F./in.	Electrical Resistivity (32°F.) ohms/cir. mil ft.	Tensile Modulus of Elasticity 10^{-6} psi.	Torsional Modulus of Elasticity 10^{-6} psi.
"D" Nickel	Annealed	35	75	40	140	0.317	8.78	2600	0.11	7.4	335	110	30	11
	Hot-rolled	50	90	35	150									
	Cold-drawn	80	100	25	190									
Low-Carbon Nickel	Annealed	15	60	50	90	0.321	8.89	2615-2635	0.11	7.2	420	50	30	11

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New Instrument to Study Gusts; NACA Velocity-Gravity-Height Recorder. *Aviation Week*, Vol. 52, No. 25, June 18, 1951, pp. 39, 40, 44, 47, illus.

Dynamic Flow-Field Measurement. Angelo Perone. *Aero Digest*, Vol. 62, No. 6, June, 1951, pp. 50, 78, 80, 82, illus.

Spherical-headed and wedge-shaped probes of various sizes with Sierra flush-mounted cells eliminate phase and amplitude errors in the study of pressure-head and angular-flow fluctuations. The probes can be used for sub- and supersonic flow conditions.

The Theory of W Function Cams. G. N. Harvey. *Society of Instrument Technology, Transactions*, Vol. 3, No. 2, June, 1951, pp. 88–96, illus., tables. 4 references.

The W Function Cam Applied to the Correction of Instrumental Errors. G. N. Harvey. *Society of Instrument Technology, Transactions*, Vol. 3, No. 2, June, 1951, pp. 80–87, illus. 6 references. Application to periodic errors in the Admiralty Transmitting Magnetic Compass (ship).

A Study of the Requirements for Letters, Numbers, and Markings To Be Used on Trans-Illuminated Aircraft Control Panels. III—The Effect of Stroke-Width and Form upon the Legibility of Numerals. Fred R. Brown, Edward A. Lowery, and Marion P. Willis. *U.S., Naval Air Experiment Station, Aeronautical Medical Equipment Laboratory, Philadelphia, Report TED No. NAM EL-609*, May 24, 1951. 32 pp., illus. 19 references.

Visibility of Characters at Low Levels of Illumination. L. J. Boardman and L. H. Dawson. *U.S., Naval Research Laboratory, Washington, Report No. 3740*, September 20, 1950. 26 pp., illus. 3 references.

Laboratory examination of self-luminous and phosphorescent materials for illuminating dials, station markers, and emergency signs for use in darkness; characteristics of these materials and their legibility with various stages of the dark-adapted eye.

A Null Method Mercury Cistern Manometer. K. R. Honick. *Journal of Scientific Instruments*, Vol. 28, No. 5, May, 1951, pp. 140–142, illus.

Design and uses of an instrument for the calibration of aircraft instruments over a pressure range of ±1 atm. to an accuracy within 0.01 in. The instrument is transportable and does not require recalibration after cleaning or dismantling.

Carrier Strain Gage Systems. Alvin B. Kaufman. *Radio & Television News*, Vol. 46, No. 1, July, 1951, *Radio-Electronic Engineering*, pp. 7–9, illus.

Use of an a.c. power supply for the strain-gage bridge for measuring low strains and dynamic loading. A continuous record of simultaneous forces is obtained by a unit consisting of the a.c. carrier amplifier system plus a recording oscillograph.

Misure Estensimetriche a Temperatura Variabile. Giuseppe Muscettola. *L'Ingegnere*, Vol. 25, No. 2, February, 1951, pp. 133–138, illus. 2 references. In Italian.

Examination of the effects of temperature variation on deformation measurements made with resistance-wire strain gages; experimental verification of a proposed expression for these effects; analysis of the influence of varying temperature on the resistance of the measuring circuits as a whole.

The Measurement of Surface Temperature. R. C. Parker. *Society of Instrument Technology, Transactions*, Vol. 3, No. 2, June, 1951, pp. 54–64, Discussion, pp. 65–67, illus. 54 references.

Evaluation of instruments for measurement of surface temperature above and below 700°C. with and without actual contact with the surface. An instrument, based on a photoconductive cell, is designed for measurement of rapidly fluctuating temperatures down to 100°C.

The Design of Thermistor Thermometers with Linear Calibration. W. R. Beakley. *Journal of Scientific Instruments*, Vol. 28, No. 6, June, 1951, pp. 176–179, illus. 2 references.

Laws & Regulations (44)

International Airline Collaboration in Traffic Pools, Rate-Fixing, and Joint Management Agreements. I. Walter H. Wager. *Journal of Air Law and Commerce*, Vol. 18, No. 2, Spring, 1951, pp. 192–199. 8 references. History of pooling arrangements; uniform fares and charges.

Observations on the Economic Regulations of the Civil Aeronautics Board. John Magnusson. *Journal of Air Law and Commerce*, Vol. 18, No. 2, Spring, 1951, pp. 181–191. 22 references.

Primary Jurisdiction of the Civil Aeronautics Board in Anti-Trust Cases. Allen H. Meyer. *Journal of Air Law and Commerce*, Vol. 18, No. 2, Spring, 1951, pp. 238–246, 48 references.

Machine Elements (14)

Machine Design Data Sheet: Design Factors for Stress Concentration. IV—Fillets in Tension and Torsion. R. E. Peterson. *Machine Design*, Vol. 23, No. 6, June, 1951, pp. 173–177, illus. 4 references.

BEARINGS

Preliminary Investigation of Wear and Friction Properties Under Sliding Conditions of Materials Suitable for Cages of Rolling-Contact Bearings. Robert L. Johnson, Max A. Swikert, and Edmond E. Brisson. *U.S., N.A.C.A., Technical Note No. 2384*, June, 1951. 33 pp., illus. 11 references.

Journal Bearings with Hydrodynamic Lubrication. W. Froessel. (*Stahl und Eisen*, Vol. 71, No. 3, February 1, 1951, pp. 125–128.) *Engineers' Digest*, Vol. 12, No. 5, May, 1951, pp. 154, 155, illus.

FASTENINGS

Hinges for Fastening Structural Parts. Harold G. Brilmyer. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 153–155, illus.

Forms of piano-type hinges for aircraft applications. The hinges are machined from high-strength aluminum-alloy extrusions. The optimum design equation is given and illustrated by a chart showing ultimate strength data for three different alloys.

FRICTION

The Mechanism of Dry Friction. Robert S. Sherwood. *Iowa State College, Iowa Engineering Experiment Station, Engineering Report No. 6*, 1950–1951. 8 pp. 10 references. Review of prevailing theory; presentation of a new concept that includes the force needed to overcome adhesion of the surfaces in the definition of dry friction.

Frictional Properties of Tungsten Carbide and of Bonded Carbides. K. V. Shooter. *Research*, No. 4, March, 1951, pp. 136–139, illus. 2 references. Reprint.

Friction Between Rubbing Surfaces. E. A. Smith. *Aeronautics*, Vol. 24, No. 5, June, 1951, pp. 71, 72, illus. Brief review of studies in Great Britain and U.S. on friction during the past 10 years.

GEARS & CAMS

Tooth Contact Layouts for Spur and Helical Gears. Harold M. Durham. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 136–140, illus.

Simplified method for the construction of layouts used in making graphical studies and investigations of tooth contact obtained in meshing pairs of involute spur gears and of helical gears. A chart is included giving the percentage of overlap obtained with different values of face width, nominal pitch, and nominal helix angle.

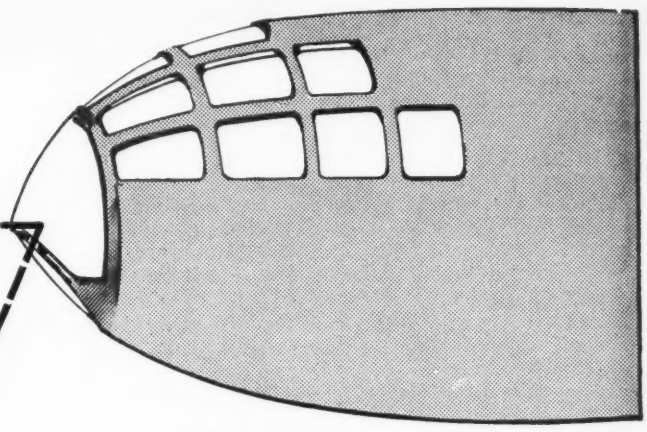
Research on the Selection of the Tooth Form of Involute Spur Gears and the Tooth-Cutting Process, for the Purpose of Improving the Quietness of Running. Takashi Nakada. *Tokyo Institute of Technology, Bulletin, Series A*, No. 1 (*Research Laboratory for Precision Machinery, Report No. 1*), 1949, pp. 1–126, illus., tables. 16 references. In Japanese; English summary.

MECHANISMS & LINKAGES

Straight-Line Motion Produced by Simple Mechanisms. Paul Grodzinski. *Machine Design*, Vol. 23, No. 6, June, 1951, pp. 125–127, illus. 4 references.

SHAFTS & ROTATING DISCS

Influence of Tensile Strength and Ductility on Strengths of Rotating Disks in Presence of Material and Fabrication Defects of Several Types. Arthur G. Holms, Joseph E. Jenkins, and



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Andrew J. Repko. *U.S., N.A.C.A., Technical Note No. 2397*, June, 1951. 39 pp., illus. 3 references.

Data on the strength-reducing effects of defects on discs of cast ceryllium copper, forged age-hardenable 18-8 stainless steel, and cast magnesium at various ductilities. Defects induced laminar-type irregularities, eutectic melting, and shrink porosity.

Maintenance (25)

Maintenance and Overhaul at Sabena. James Hay Stevens, *Aircraft Engineering*, Vol. 23, No. 268, June, 1951, pp. 163–172. 181, illus. Systems, methods, and overall maintenance organization of Sabena's facilities at Melsbroek and Haren airports; DC-3, DC-4, DC-6, and Convairliners are handled.

Materials (8)

Improvements in the Design of Ultrasonic Lamination Detection Equipment. H. R. Clayton and R. S. Young. *Journal of Scientific Instruments*, Vol. 28, No. 5, May, 1951, pp. 129–132, illus. 3 references.

Design details of an apparatus for the detection of lamination in sheet aluminum performance. The simple transmission technique as used by Sokolov has been modified in order to minimize the effect of standing waves, which are formed in sheets of specific thicknesses.

CERAMICS & CERAMALS

Effectiveness of Ceramic Coatings in Reducing Corrosion of Five Heat-Resistant Alloys by Lead-Bromide Vapors. Dwight G. Moore and Mary A. Mason. *U.S., N.A.C.A., Technical Note No. 2380*, June, 1951. 27 pp., illus. 10 references.

Investigation of the corrosive effects of lead bromide vapor on Inconel, A.I.S.I. type 347 and 19-9DL stainless steels, Vitallium, and S-816 heat-resistant alloys at 1,350°, 1,500°, and 1,650°F. The specimens were tested uncoated, preoxidized, and with three ceramic coatings. Results are tabulated.

Studies on High-Temperature Protection of a Titanium-Carbide Ceramal by Chromium-Type Ceramic-Metal Coatings. Dwight G. Moore, Stanley G. Benner, and William N. Harrison. *U.S., N.A.C.A., Technical Note No. 2386*, June, 1951. 26 pp., illus. 5 references.

Rocket Linings. W. H. Duckworth and H. Z. Schofield. (*A.S.M.E.–American Rocket Society, Semi-Annual Meeting, Toronto, June 11–14, Preprint.*) *Aviation Week*, Vol. 54, No. 26, June 25, 1951, pp. 31, 33, 34, 36, illus. Ceramic linings for rocket motors; conclusions drawn from tests on ceramic-lined rocket motors of 250- and 1,000-lb. thrust; causes of failure.

Ryan Lengthens Exhaust Manifold Life. Wilson G. Hubbell. *Aviation Age*, Vol. 15, No. 6, June, 1951, p. 23, illus. Application of thin ceramic coatings.

METALS & ALLOYS

Fatigue Strengths of Aircraft Materials; Axial-Load Fatigue Tests on Notched Sheet Specimens of 24S-T3 and 75S-T6 Aluminum Alloys and of SAE 4130 Steel with Stress-Concentration Factors of 2.0 and 4.0. H. J. Grover, S. M. Bishop, and L. R. Jackson. *U.S., N.A.C.A., Technical Note No. 2389*, June, 1951. 64 pp., illus., tables. 8 references.

Fatigue Strengths of Aircraft Materials; Axial-Load Fatigue Tests on Notched Sheet Specimens of 24S-T3 and 75S-T6 Aluminum Alloys and of SAE 4130 Steel with Stress-Concentration Factor of 5.0. H. J. Grover, S. M. Bishop, and L. R. Jackson. *U.S., N.A.C.A., Technical Note No. 2390*, June, 1951. 19 pp., illus. 2 references.

Influence of Tensile Strength and Ductility on Strengths of Rotating Disks in Presence of Materials and Fabrication Defects of Several Types. Arthur G. Holms, Joseph E. Jenkins, and Andrew J. Repko. *U.S., N.A.C.A., Technical Note No. 2397*, June, 1951. 39 pp., illus. 3 references. Data on the strength-reducing effects of defects on discs of cast beryllium copper, forged-age-hardenable 18-8 stainless steel, and cast magnesium at various ductilities.

Preliminary Investigation of Wear and Friction Properties Under Sliding Conditions of Materials Suitable for Cages of Rolling-Contact Bearings. Robert L. Johnson, Max A. Swikert, and Edmond E. Brisson. *U.S., N.A.C.A., Technical Note No. 2384*, June, 1951. 33 pp., illus. 11 references. Apparatus and results of dry sliding tests of SAE 52100 steel, brass, beryllium copper, bronze, Monel, Inconel X, 24S-T aluminum, nodular iron, and gray cast iron.

The Development of Deformation Textures in Metals. II—Body-Centred Cubic Metals. E. A. Calnan and C. J. B. Clews. *Philosophical Magazine*, Vol. 42 (7th Series), No. 329, June, 1951, pp. 616–635, illus. 13 references.

Materials Engineering File Facts No. 210: Thermal Conductivity of Various Materials vs. Temperatures. *Materials & Methods*, Vol. 33, No. 6, June, 1951, p. 107, illus.

A Hundred Years of Metallurgy, 1851–1951. II. Leslie Aitchison. *Sheet Metal Industries*, Vol. 28, No. 290, June, 1951, pp. 519–526, 530, illus.

The Study of Sintering Phenomena by Means of Continuous Contraction Measurements. S. Tacvorian and M. Lévêcque. (*La Recherche Aéronautique*, No. 12, January-February, 1951, pp. 49–58.) *Engineers' Digest*, Vol. 12, No. 5, May, 1951, pp. 155–158, illus.

Cooperative Investigation of Relationship Between Static and Fatigue Properties of Heat-Resistant Alloys at Elevated Temperatures. N.A.C.A. Subcommittee on Heat-Resisting Materials. *U.S., N.A.C.A., Research Memorandum No. 51A04*, March 7, 1951. 51 pp., illus., tables.

Data covering combinations of steady tensile stress with superimposed dynamic stress, and completely reversed-stress fatigue tests on 1-in. round low-carbon N-155 alloy bar stock at room temperature, and at 1,000°, 1,200°, 1,350°, and 1,500°F. Curves relate alternating stress to mean stress for fracture in 50, 100, and 500 hours. Specimen preparation and testing procedure and apparatus are described.

Effect of Chromium Plating on the Plastic Deformation of SAE 4130 Steel. Hugh L. Logan. *U.S., National Bureau of Standards, Journal of Research*, Vol. 46, No. 6, June, 1951, pp. 472–479, illus. 4 references. Also available as *Research Paper No. 2216*. Superintendent of Documents, Washington. $0.10.

Analysis of results of tensile, tensile-impact, and bending tests to evaluate the effects of chromium plating on the plastic deformation of SAE 4130 rod and tubing. Plated specimens were tested before and after various baking treatments.

Fatigue Loss and Gain by Electroplating. J. O. Almen. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 109–116, illus. 14 references.

Explanation of the effect of electrodeposited metals on the fatigue strength of steels; measurements of residual stress; measurements and fatigue endurance in Cr plate; surface vulnerability and applied loads; variation in residual stress; controlled stress in Ni deposits; mechanical prestressing; interpretation of laboratory analyses.

Discussion: Engineering Steels Under Combined Cyclic and Static Stresses, by H. J. Gough. H. Majors, Jr., W. N. Findley, T. J. Dolan, John M. Lessells, and R. E. Peterson. **Author's Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 211–216, illus. 5 references.

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Investigations on the Deformations of Steels Due to Heat-Treatment. Minoru Tanaka. *Tokyo Institute of Technology, Bulletin, Series A*, No. 2 (*Research Laboratory for Precision Machinery, Report No. 2*), 1949, pp. 1–76, illus., tables. 31 references. In Japanese; English summary.

Fundamental Aging Effects Influencing High-Temperature Properties of Solution-Treated Inconel X. D. N. Frey, J. W. Freeman, and A. E. White. *U.S., N.A.C.A., Technical Note No. 2385*, June, 1951. 71 pp., illus. 8 references.

Studies of the mechanisms by which aging treatments influence the mechanical properties of Inconel X at temperatures of 1,200° and 1,500°F. for time periods up to 1,000 hours. The results are compared with previous work on low-carbon N-155 alloy.

Observations on Bauschinger Effect in Copper and Brass. H. Schwartzbart, M. H. Jones, and W. F. Brown, Jr. *U.S., N.A.C.A., Research Memorandum No. E51D13*, June 19, 1951. 37 pp., illus. 19 references.

A study of the Bauschinger effect, a residual stress phenomenon associated with the fact that prestrain in tension actually weakens the material in subsequent compression. Experiments were performed to determine the variation of the Bauschinger effect with prestrain, the effect of heat treatment on the Bauschinger effect, and its behavior in cubically aligned copper sheet.

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Discussion on "Plastic Biaxial Stress-Strain Relations for Alcoa 24S-T Subjected to Variable-Stress Ratios," by Joseph Marin and B. J. Kotalik. D. C. Drucker. **Author's Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, p. 221. 1 reference.

Some Considerations on the Plastic Behavior of a Light Metal. Hisao Mii. *Japan Society for Applied Mechanics, Journal*, Vol. 4, No. 21, January, 1951, pp. 9–14, illus. 4 references.

Analysis of results of tension and compression tests on 98.85 per cent pure aluminum to study the transition from the elastic to the plastic state and the conditions of deformation.

Materials & Methods Manual No. 71: Wrought Aluminum Alloys. Philip O'Keefe. *Materials & Methods*, Vol. 33, No. 6, June, 1951, pp. 89–104, illus.

Nomenclature and alloy composition; available forms; physical and mechanical properties; corrosion and chemical resistance; working wrought alloys; joining aluminum; and finishes for aluminum.

Materials Engineering File Facts No. 209: Characteristics and Applications of Standard Aluminum Rivet Alloys and Tempers. *Materials & Methods*, Vol. 33, No. 6, June, 1951, p. 105, table.

NONMETALLIC MATERIALS

Uses of Commercial Silicone Products. R. O. Sauer. *General Electric Review*, Vol. 54, No. 6, June, 1951, pp. 39–44, illus. Methods of preparation; composition; characteristics; applications.

Aircraft Adhesives, Sealers, and Coatings. I. G. Christensen. *Aeronautical Engineering Review*, Vol. 10, No. 8, August, 1951, pp. 10–16, illus. Advantages of adhesives as fasteners; types of adhesive bonds; types and applications of sealers and coatings.

Effect of Fuel Immersion on Laminated Plastics. W. A. Crouse, Margie Carickhoff, and Margaret A. Fisher. *U.S. N.A.C.A., Technical Note No. 2377*, June, 1951. 34 pp., illus. 2 references.

Results of tests at 77°F. on 19 laminated plastics (phenolic laminates and experimental materials for aircraft applications) to study the effects of cyclic and continuous immersion in heptane, toluene, and SR-6 fuel blend on the weights, dimensions, and flexural properties.

Effects of Molding Conditions on Some Physical Properties of Glass-Fabric Unsaturated-Polyester Laminates. John E. Wier, Dorothy C. Pons, and Benjamin M. Axilrod. *U.S., N.A.C.A., Research Memorandum No. 50J19*, November 9, 1950. 26 pp., illus. 8 references.

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SANDWICH MATERIALS

Reference Book Sheet: Buckling Strength of Rectangular Sandwich Panels. N. J. Hoff. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 183, 185, illus. Charts for obtaining the buckling load.

Buckling of a Sandwich Cylinder Under Uniform Axial Compressive Load. A. Cemal Eringen. *Journal of Applied Mechanics*, Vol. 18, No. 2, June, 1951, pp. 195–202, illus. 10 references.

Derivation of a formula for determining the buckling load of a circular sandwich cylinder with compressive loads uniformly distributed on the ends of the faces. The boundary-value problem in elasticity which is solved by the small-deflection theory is developed in terms of four arbitrary deflection functions. The longitudinal component of stress and the radial displacements are zero on the ends of the cylinder. The critical load is given by the eigenvalues of two simultaneous differential equations of equilibrium which are obtained in terms of the deflections. This solution may be considered as the first instability problem of a sandwich-type airplane fuselage.

Newest Methods of Fabricating Honeycomb Aircraft Components. T. F. Freeman. *Automotive Industries*, Vol. 104, No. 12, June 15, 1951, pp. 42–45, 130, illus. Production processes in the fabrication of the elevon for the Northrop Flying Wings; core construction; assembly; curing; testing.

Meteorology (30)

Relaxation Methods and Their Application to Meteorological Problems. F. H. Bushby. *Meteorological Magazine*, Vol. 80, No. 945, March, 1951, pp. 71–77, illus. 4 references.

Electron-Microscope Study of Fog Nuclei. Daisuke Kuroiwa. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 157–160, illus. 5 references.

Correspondence: Drop Size and Relative Mass Contributed in Rain. J. Neumann. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 205, 206, illus. 3 references.

Electron-Microscope Study of Snow-Crystal Nuclei. Motoi Kumai. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 151–156, illus. 6 references.

The Influence of Temperature on the Shape of Ice Crystals Growing at Water Saturation. H. J. aufm Kampe, H. K. Weickmann, and J. J. Kelly. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 168–174, illus. 11 references.

On the Maintenance of Zonal Circulation in the Atmosphere. Tu Cheng Yeh. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 146–150. 12 references. Study of the maintenance of a jet-type zonal circulation from the point of view of vorticity balance.

Remarks on "Possible Effects of Ozonosphere Heating on Sea-Level Pressure," by H. Wexler. R. G. Gleagle. **Author's Reply.** *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 200–202. 3 references.

La "Corrente a Getto." Raoul Bilancini. *Rivista di Meteorologia Aeronautica*, Vol. 10, No. 3, July–September, 1950, pp. 3–13, illus. 32 references. In Italian. State of knowledge of the jet stream, its relationship to other weather processes, and its applications to forecasting.

Coordinate Systems in Dynamic Meteorology. G. C. McVittie. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 161–167. 5 references.

Correspondence: Upper-Level Vortices and the Turbulent Transfer of Momentum. G. J. Haltiner. **Reply.** Yi-Ping Hsieh. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 202–205, illus. 2 references.

Correspondence: On Motion with Constant Relative Vorticity. Plácido Jordán. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, p. 199.

A Wind-Tunnel Investigation of the Limitations of Thermistor Anemometry. Edward R. Sanford. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 182–190, illus. 5 references.

Radiotransmissione di Carte Meteorologiche. Nicola Morasca. *Rivista di Meteorologia Aeronautica*, Vol. 10, No. 3, July–September, 1950, pp. 29–31. 1 reference. In Italian. Preliminary design of a pantograph system for radio transmission and reception of isobaric, contour, and other meteorological charts.

Essay on Frontogenesis and Frontolysis. II—Deformation Field and Circulations in the Vertical Plane. H. H. Lamb. *Meteorological Magazine*, Vol. 80, No. 945, March, 1951, pp. 65–71, illus. 6 references.

Forecasting the Weather; Forecasting the Duration of Low Clouds Following Cold Front Passages at Elkins, West Virginia. Robert A. Hoover. *Weatherwise*, Vol. 4, No. 3, June, 1951, pp. 62, 63, illus.

Tropospheric and Stratospheric Temperature Changes Associated with Pressure Changes. J. M. Austin and R. Shapiro. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 191–195, illus. 7 references.

Ricerche di Correlazioni Ionosferico-Meteorologiche. Aldo Napoletano. *Rivista di Meteorologia Aeronautica*, Vol. 10, No. 3, July–September, 1950, pp. 18–22, illus. In Italian.

Summary of research on ionospheric-meteorological correlations with reference to the *E*-layer, including recent work at the Centro Radiopropagazione de Radionavigazione, Naples.

Charge Densities in the Ionosphere from Radio Doppler Data. Warren W. Berning. *Journal of Meteorology*, Vol. 8, No. 3, June, 1951, pp. 175–181, illus. 6 references.

Determination of ionospheric structure from errors in reductions of data from the DOVAP electronic tracking system. An equation is developed for obtaining the ionization densities from DOVAP records, along with a procedure for determining the relatively exact vacuum trajectory of the missile. A study of readings from the V-2 illustrates the technique.

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Military Aviation (24)

Strategic Air Warfare. R. A. Ofstie. *U.S. Naval Institute, Proceedings*, Vol. 77, No. 6, June, 1951, pp. 591–598. Explanation; World War II experiences; future applications.

Navigation (29)

Navigational Trace Guide. *Wireless World*, Vol. 57, No. 1, January, 1951, pp. S.17–S.20, illus.

A track control unit for use with a Decca Navigator receiver. The instrument, produced by Wayne Kerr Laboratories, is an electromechanical computer that gives direct readings of the divergence from a preselected course and the distance traveled along that course in nautical miles.

The Decca Flight Log. M. R. Aries. *The Log*, Vol. 11, No. 6, June, 1951, pp. 149–155, illus.

Anyone Can Fly a Pressure Pattern. Donald G. Williams. *Aero Digest*, Vol. 62, No. 6, June, 1951, pp. 30, 31, 62, 66, 68, 70, 72, 74, 76, 78, illus. Experiences of MATS; limitations and advantages. A single drift correction is computed to compensate for the net effect of wind on the course.

Photography (26)

Panoramic Camera Has Electronic Controls. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 124–126, illus.

A transverse panoramic camera in which a 90-lb. scanning prism can be rotated through a 180° arc; an 18-in. wide strip of photographic film is moved across a 2-in. slit. The camera, manufactured by Perkins-Elmer Corp., has a five-element lens with a focal length of 48 in. After focusing, electronic servos control the camera's operation. Photographs and diagrams show the control mechanism.

Power Plants

The Atom-Power for Flight. II–IV. David A. Anderton. *Aviation Week*, Vol. 54, Nos. 22–24, May 28, June 4, 11, 1951, pp. 23, 24, 27–30; 21, 22, 24, 27, 28, 30; 21, 22, 25, 26, 29–32; illus.

Nuclear reactor design and construction materials; design and installation considerations of nuclear energy ram-jet and turbojet power plants; an atomic-powered flying boat.

Atomic Power Plants for Aircraft. *Interavia*, Vol. 6, No. 5, May, 1951, pp. 246, 247, illus. 7 references.

Structural principles for aircraft reactors; diagrams and general information on four types of engines with atomic reactors: mercury-vapor or helium turbine, jet turbine engine, ram-jet, and hydrogen rocket.

On a Theory of Polar Forces As a Principle for Application of Atomic Energy to Rocket Propulsion. I. Hans J. Kaeppeler. *Rocketscience*, Vol. 5, No. 2, June, 1951, pp. 34–41, illus. 20 references.

Physical fundamentals; analysis of the force ratio between two singularities in a field based on an extension of the theory of polar faces for fields of atomic dimensions to matter and energy fields of any dimensions.

The Efficiency of Heat Engines. II. (*Teknisk Tidskrift*, Vol. 80, No. 46, December 16, 1950, pp. 1157–1164.) *The Engineers' Digest*, Vol. 12, No. 5, May, 1951, pp. 149–152, illus. 5 references. Development of general efficiency formulas; application to six types of heat machines

JET & TURBINE (5)

Centrifugal Steel Castings; Foundry Methods and Process Control in Producing Gas-Turbine Components (David Brown Foundries, Ltd.). J. Taylor and D. H. Armitage. *Aircraft Production*, Vol. 13, No. 152, June, 1951, pp. 167–169, illus.

Performance Investigations of a Large Centrifugal Compressor from an Experimental Turbojet Engine. Ambrose Ginsburg, John W. R. Creagh, and William K. Ritter. *U.S., N.A.C.A., Research Memorandum No. E8H13*, October 18, 1948. 54 pp., illus. 6 references. Performance characteristics and airflow analysis; aerodynamic problems of large centrifugal-type compressors for turbojet engines.

Automatic Control Systems Satisfying Certain General Criterions on Transient Behavior. Aaron S. Boksenbom and Richard Hood. *U.S., N.A.C.A., Technical Note No. 2307*, June, 1951. 45 pp., illus. 6 references.

Development of a general procedure of control synthesis which gives a set of equations, based on physically realizable criteria for the optimum control systems. The methods apply the calculus of variations to minimize certain time integrals. The general results are applied to the design of turbojet engine controls.

The Thrust and Drag Penalties on a Jet Engine Installation Due to Cooling Flow. Harold Klein. *Douglas Aircraft Company, Inc., Report No. SM-13862*, November 7, 1950. 14 pp., illus.

Analysis for estimating the fractional net thrust penalty due to cooling shroud on a turbojet nozzle. In-flight thrust of an engine without a cooling shroud is compared with that of a shrouded installation. An experimental procedure was devised to obtain the gross thrust penalty.

Analytical Solutions for Gross Thrust Change and Weight Flow Ratio Due to a Jet Ejector Pump. N. L. Fox. *Douglas Aircraft Company, Inc., Report No. SM-13881*, December 1, 1950. 27 pp., illus. 1 reference. Theoretical analysis of variables for a simple frictionless jet pump to estimate the net thrust change due to a jet-pump cooling system.

Power Improvements in Turbojets. Paul H. Wilkinson. *Aviation Age*, Vol. 15, No. 6, June, 1951, pp. 34, 35, illus. U.S. and British turbojet power increases and engine modifications, 1947–1951.

The Development of the Avro Orenda Jet Propulsion Engine. D. W. Knowles. *American Society of Mechanical Engineers, Semi-Annual Meeting, Toronto, June 11–14, 1951, Preprint.* 24 pp., illus. 7 references.

Gas Turbine Design Based on Free Vortex Flow. E. A. Simonis and J. Reeman. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2541*, 1951 (May, 1944). 23 pp., illus. 3 references. British Information Services, New York. $1.15.

Penetration of Liquid Jets into a High-Velocity Air Stream. Louis J. Chelko. *U.S., N.A.C.A., Research Memorandum No. E50F21*, August 14, 1950. 23 pp., illus. 2 references.

Investigation of penetration characteristics of water jets directed approximately perpendicularly to a high-velocity air stream to obtain design information of nozzles of turbojet engines with thrust augmentation.

Flight Tests of a Meteor I with Two W2/B23 Turbine Engines Equipped with Modified Jet Pipe Reheating. A. D. Baxter and C. Kell. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2422*, 1951 (April, 1945). 12 pp., illus. 4 references. British Information Services, New York. $0.65.

RAM-JET

Method for Calculation of Ram-Jet Performance. John R. Henry and J. Buel Bennett. *U.S., N.A.C.A., Technical Note No. 2357*, June, 1951. 95 pp., illus. 12 references.

A simplified method of obtaining ram-jet performance uses charts showing precalculated solutions. The charts cover a flight Mach Number range of 0 to 4.0, combustion-chamber inlet Mach Numbers from 0 to 0.5, combustion-chamber temperature rise above that obtainable with gasoline-air mixtures, and all possible values of diffuser total-pressure recovery ratio and combustion chamber and exhaust-nozzle total-pressure ratio.

A Cheap Power Unit for Light Aircraft. II. Peter Kahn and F. Clay. *The Aeroplane*, Vol. 80, No. 2080, June 1, 1951, pp. 664, 665, illus.

Practical aspects of the performance of a ram-jet-powered propeller for light aircraft. Experiments were carried out to study power-plant size for a specific thrust, end-plate effects, fuel-supply problems, internal and external drag, and methods of starting the engine. Several burner designs were tested in the determination of net thrust.

RECIPROCATING (6)

Study of Compressor Systems for a Gas-Generator Engine. Berhard I. Sather and Max J. Tauschek. *U.S., N.A.C.A., Research Memorandum No. E50H08*, October 16, 1950. 49 pp., illus. 4 references.

Evaluation of engine performance as a function of altitude of various combinations of compressors and driving mechanisms to study compressor-capacity and pressure-ratio control in the gas-generator type of compound engine. Altitude range was 0–50,000

ft. The performance of the combinations is compared with that of an ideal engine.

The Design of Bearings for Piston Engines; Application of the Theory of Effective Loads. III—Several Observations on the Application of the Theory of Effective Loads to the Design of Engine Bearings. A. K. Diachkov. (*Akademiia Nauk S.S.S.R., Leningrad, Izvestiia*, No. 11, November, 1950, pp. 1615–1644.) *The Engineers' Digest*, Vol. 12, No. 5, May, 1951, pp. 163, 164, illus.

Een Typisch Breukgeval bij een Cylinder van een Luchtgekoelde Vliegtuigmotor. G. Broersma. *De Ingenieur in Indonesië*, No. 1, 1951, pp. III.1–III.12, illus. 3 references. Reprint. In Dutch.

Analysis of the stresses in the cylinder of an air-cooled aircraft engine, based upon a case of fracture of the aluminum cylinder heads of an engine of a three-engined flying boat of recent design.

Air Force Developing Multifuel Lightweight Diesel. M. E. Davis and F. J. Neugebauer. *Automotive Industries*, Vol. 104, No. 12, June 15, 1951, pp. 32, 33, 132, 134, 136, illus.

ROCKET (4)

Chemical Kinetics and Rocket Nozzle Design. F. J. Krieger. *The RAND Corporation, Report No. R-203*, August, 15, 1950. 27 pp., illus., tables. 5 references.

Analysis of the effect of chemical kinetics for a convergent-divergent rocket nozzle of the Laval type with a chamber-to-throat area ratio of 2:1 and adiabatic gas flow. Hydrogen gas entered the nozzle at 3,500°F. and 20 atm. pressure; the gas expanded isentropically to a pressure of 1 atm. Tables give the computed values for the adiabatic expansion of hydrogen at a mass flow rate of 1,000 gm. per sec. over a temperature range of 1,600–3,500°K. for constant composition, instantaneous chemical equilibrium, and kinetic chemical equilibrium. A stepwise integration procedure was used to compute the last case.

Determination of Rocket-Motor Heat-Transfer Coefficients by the Transient Method. Stanley Greenfield. *Journal of the Aeronautical Sciences*, Vol. 18, No. 8, August, 1951, pp. 512–518, 526, illus. 5 references.

Development of an experimental procedure. A copper rocket-nozzle was designed for gas-film-coefficient studies on a rocket motor of 1,000-lbs. thrust. Test equipment and procedure are explained. Results of tests at temperatures of 1,400 and 3,000°F. are plotted.

Combustion in the Rocket Motor. A. D. Baxter. *British Interplanetary Society, Journal*, Vol. 10, No. 3, May, 1951, pp. 123–138, illus. 10 references.

Injection, ignition, and combustion in a rocket motor giving a 5,000-lb. thrust, assuming that the liquid oxidant and liquid fuel are injected separately. The mechanism of atomization of the fuel and oxidant is explained. The behavior of a droplet and the changes it undergoes are studied throughout the process.

The Naval Air Rocket Test Station—Purpose and Progress. F. C. Durant, III. *American Rocket Society, Journal*, No. 85, June, 1951, pp. 74–79.

Throttling Thrust-Chamber Control. Marvin Meyer. *American Rocket Society, Journal*, No. 85, June, 1951, pp. 68–73, illus.

Theoretical analysis of the mechanism of variable-thrust control in rocket motors operating with liquid fuels; means of controlling propellant intake; pressure distribution of power plant.

Expellant Bags for Rocket Propellant Tanks. W. R. Sheridan. *American Rocket Society, Journal*, No. 85, June, 1951, pp. 80–82, illus.

Design and operation. A collapsed bag, contained in the tank of liquid fuel, expands as the gas enters it and forces the liquid from the tank. The propellant is continuously supplied to the motor regardless of the position or the direction of the missile. The material of the bag, fabrication method, and installation are analyzed.

Production (36)

Fighter Canopy; Manufacture of Double-Skinned Unit for the Vickers-Supermarine Attacker. *Aircraft Production*, Vol. 13, No. 152, June, 1951, pp. 180–184, illus.

Canopy and windshield construction, molding techniques, cementing operations, assembly. The canopy and windshield

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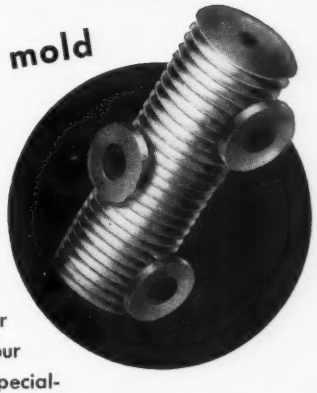

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Newest Methods of Fabricating Honeycomb Aircraft Components. T. F. Freeman. *Automotive Industries*, Vol. 104, No. 12, June 15, 1951, pp. 42–45, 130, illus. Production processes in the fabrication of the elevon for the Northrop Flying Wings; core construction; assembly; curing; testing.

Plane Fabrication's Ace in Hole; German-Developed Mass-Production Technique Being Studied by Republic for Application to Thunderjet. Irving Stone. *Aviation Week*, Vol. 54, No. 22, May 28, 1951, pp. 42, 44, 47, illus.

Solidification of Steel from Sand and Chill Walls. H. F. Bishop, F. A. Brandt, and W. S. Pellini. *U.S., Naval Research Laboratory, Washington, Report No. 3785*, January 4, 1951. 25 pp., illus. 4 references.

Thermal analyses of the heat-transfer processes occurring during the solidification of steel castings in the mold. Chill (iron) and sand walls were investigated over a range of wall thicknesses and sand conditions from green to dry. Temperatures were measured by Pt-PtRh thermocouples enclosed in quartz tubes of $^1/_{16}$-in. inside diameter; the castings in the region of the thermocouples were examined by X-ray methods. The contribution of superheat was also studied.

Relation of Casting Quality to Gating Practice. William H. Johnson, Harold F. Bishop, and William S. Pellini. *U.S., Naval Research Laboratory, Washington, Report No. 3786*, January 4, 1951. 13 pp., illus. 3 references.

Study of the effects of gate and mold-flow conditions on casting quality in finger-gating systems. The effects of flow conditions and turbulence were evaluated for steel, gray iron, manganese bronze, and aluminum. Both free and choked gating systems were studied.

Centrifugal Steel Castings; Foundry Methods and Process Control in Producing Gas-Turbine Components (David Brown Foundries, Ltd.). J. Taylor and D. H. Armitage. *Aircraft Production*, Vol. 13, No. 152, June, 1951, pp. 167–169, illus. Development of production techniques for plain ring-type castings; applications; materials used; testing methods.

A Review of Impact Extrusion and Some Related Processes. G. Sachs. *Sheet Metal Industries*, Vol. 28, No. 290, June, 1951, pp. 533–538, 546, illus. 4 references.

Reducing Cost of Extrusions. Frank McL. Mallett. *Product Engineering*, Vol. 22, No. 6, June, 1951, pp. 149–152, illus.

A Survey of Modern Theory on Welding and Weldability. III. D. Seférian. *Sheet Metal Industries*, Vol. 28, No. 290, June, 1951, pp. 553–565, illus.

Chemical compositions and mechanical and thermal characteristics of aluminum and light alloys used in welding. The techniques of oxyacetylene, electric-arc, and arc-welding in a monatomic gas are examined.

de Havilland Comet. II—Construction and Tooling of the Wing; Plaster Models; Glasscloth Molding. H. Povey. *Aircraft Production*, Vol. 13, No. 152, June, 1951, pp. 170–178, illus.

Production Developments; Some American Post-War Developments in Airframe Tooling. T. E. Piper. *Aircraft Production*, Vol. 13, No. 152, June, 1951, pp. 187–193, illus. 1 reference.

Developments of the limited-production type of tooling equipment: plastic templates and dies; use of magnesium in welding fixtures; the electroform process; flexible stretching-die; the Marform process; applications of hot-forming; fabrication procedures for 75S-T and magnesium alloy-sheet; portable riveting and hot-dimpling equipment; fusion-, spot-, and reverse-contour spot-welding; process control methods.

Optical Tooling Faces Its Biggest Test; Accuracy of Reassembly After Teardown Is Under Study for Air Force. Irving Stone. *Aviation Week*, Vol. 54, No. 25, June 18, 1951, pp. 27–32, 35, 36, illus., chart.

Improvement and evaluation program at Republic Aviation Corp. of German-developed optical tooling system for aircraft jigs and assemblies. Fixtures will be built at Republic, shipped to users, and reassembled for production work. Republic has completed the design of American standard castings that are counterparts of the German units.

Thompson Products, Inc.: Engineering Is Their Business. Gilbert P. Muir. *Tool Engineer*, Vol. 26, No. 6, June, 1951, pp. 55–63, illus.

Brief history of Thompson Products, Inc., and its chief developments; budgets, cost control, and inventories; engineering aspects, including output, testing, personnel selection and evaluation. Charts show management and quality-control forms, and personnel evaluation charts.

Tooling for Plastics Production; North American Plastics Technique. Gilbert C. Close. *Aviation Age*, Vol. 15, No. 6, June, 1951, pp. 30, 31, illus.

Giant Machine Meets Defense Schedules. J. A. Helget. *Applied Hydraulics*, Vol. 4, No. 6, June, 1951, pp. 52–55, illus. Components of the Hufford 175-hp. hydraulic stretch-wrap forming machine; operation; circuit design.

Propellers (11)

Airscrews at Supersonic Forward Speeds. J. C. Burns. *Aeronautical Quarterly*, Vol. 3, Part 1, May, 1951, pp. 23–50, illus. 11 references.

Flow past an airscrew (defined as any type of screw designed to rotate in air, such as propellers, windmills, etc.) mounted on a body and designed so that the aerodynamic rotation of the air produces a torque that tends to increase the angular velocity. The theory is demonstrated for windmills, but can be modified to apply to propellers. The problem is that of finding the flow past an airfoil fixed in a uniform supersonic stream, using the methods of Puckett, Evvard, and Ward. The disturbance potential is expanded as a power series in χ (the ratio of the tip speed to sonic speed). The first term is the exact solution derived from quasi-static theory; successive terms give higher approximations of the flow. Expressions are developed for the torque and drag and for the working conditions (efficiency and power).

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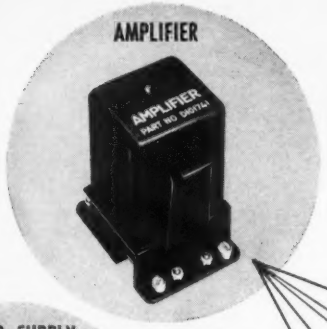
mechatronics*



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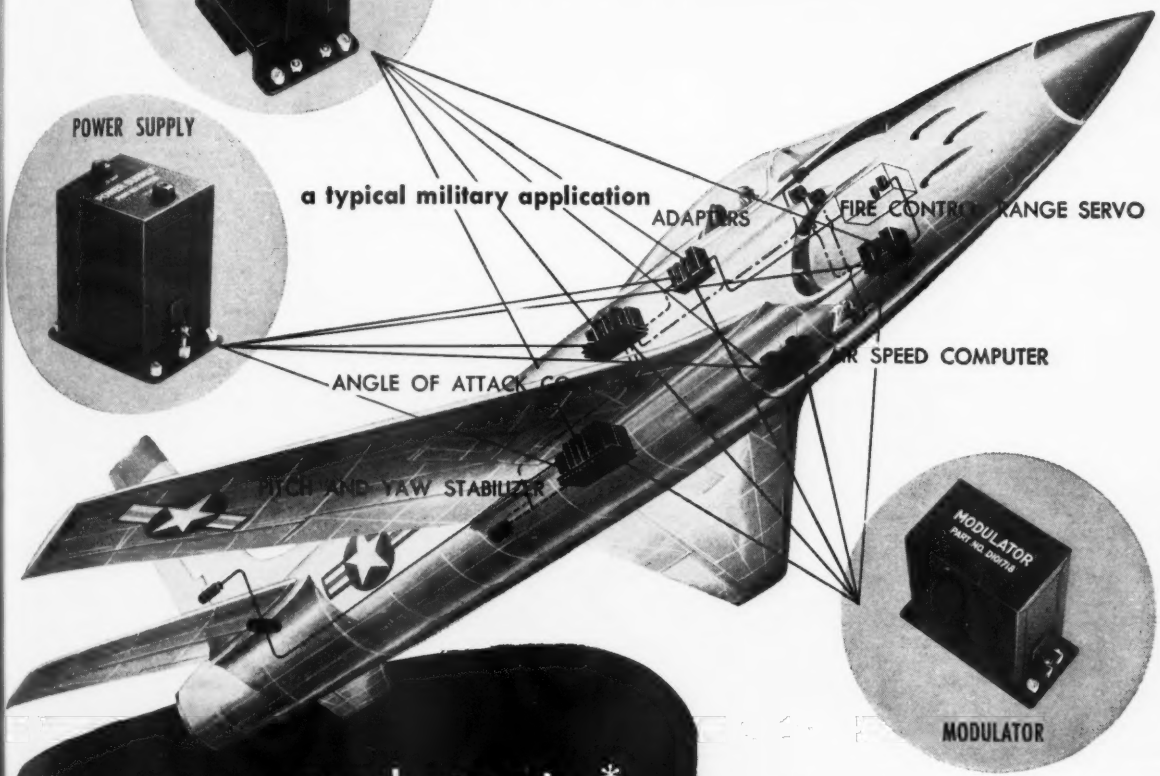

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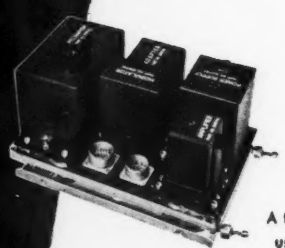

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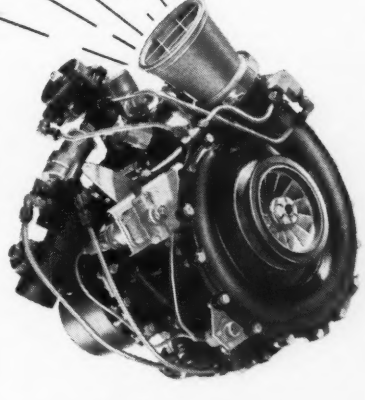

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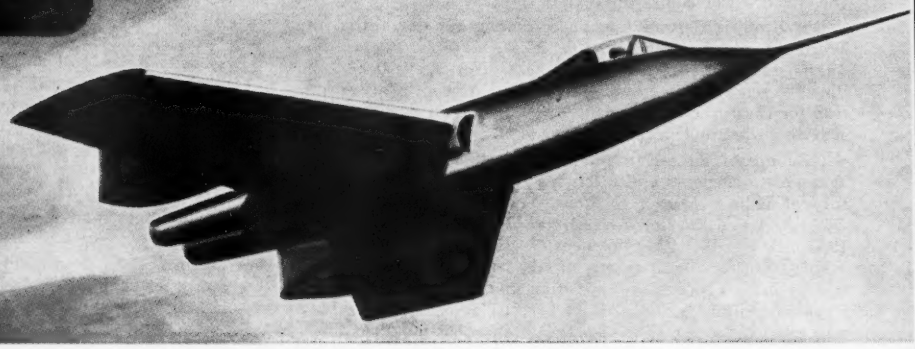

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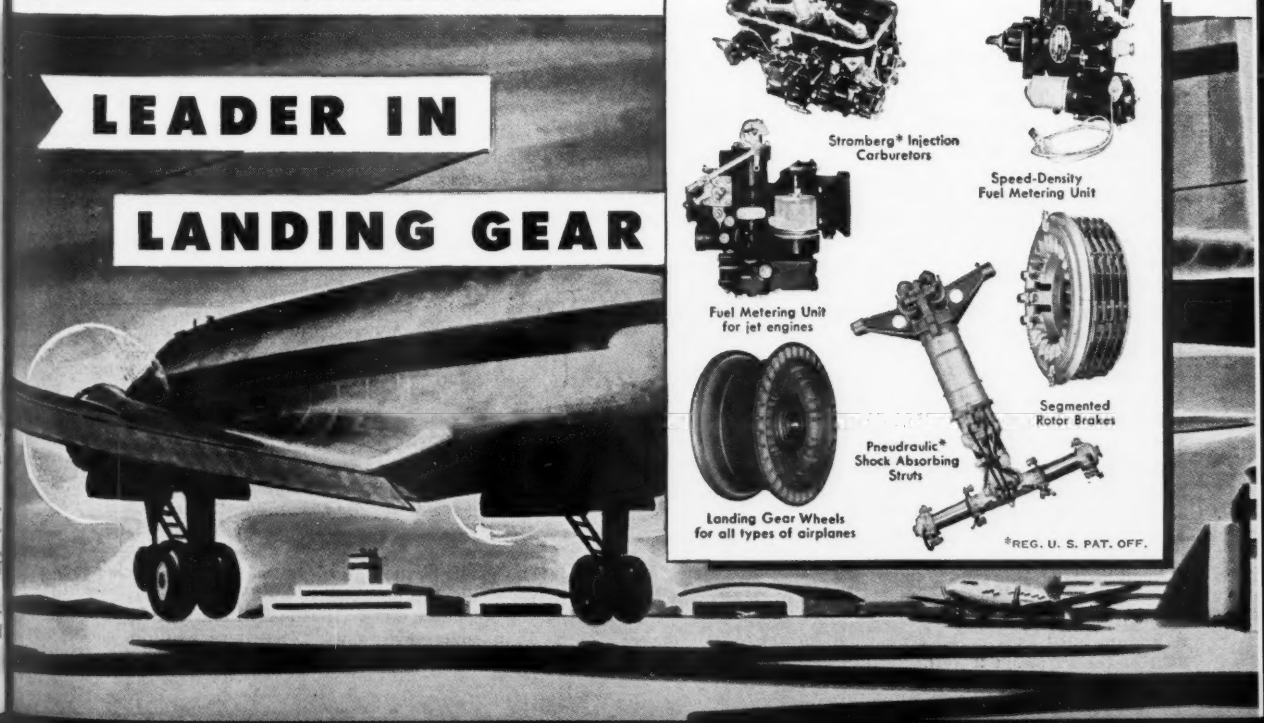

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Aerodynamics, power plant, structures and aeroelasticity, materials, equipment, and special projects undertaken by the A.R.C.; constitution of the Council, membership, committees, and subcommittees.

Investigation of Centrifugal Compressor Operated As a Centripetal Refrigeration Turbine. John J. Rebeske, Jr., Richard B. Parisen, and Harold J. Schum. *U.S., N.A.C.A., Research Memorandum No. E50I20*, December 4, 1950. 21 pp., illus. 2 references.

Analysis and tests to determine whether a centrifugal-flow compressor from a production-type turbojet engine could be used as an air-refrigeration unit in N.A.C.A. laboratory facilities when it was operated as a radial centripetal turbine. Performance data of the variation in refrigerating effect, temperature drop weight flow, and adiabatic efficiency are presented for various pressure ratios.

The Ship Model Towing Tank (M.I.T.). Martin A. Abkowitz. *Technology Review*, Vol. 53, No. 8, June, 1951, pp. 404–406, illus.

Investigation of Interaction Effects Arising from Side-Wall Boundary Layers in Supersonic Wind-Tunnel Tests of Airfoils. K. R. Czarnecki and C. F. Schueller. *U.S., N.A.C.A., Research Memorandum No. L8G27*, November 3, 1948. 27 pp., illus. 1 reference. Total- and static-pressure measurements in the test section of a 2- by 8-in. supersonic tunnel in the region of the model, with and without model installed.

Rectangular-Wind-Tunnel Blocking Corrections Using the Velocity-Ratio Method. Rudolph W. Hensel. *U.S., N.A.C.A., Technical Note No. 2372*, June, 1951. 40 pp., illus. 4 references.

Ratios of the velocities at the model to those at reference points on the tunnel wall are calculated for two-dimensional airfoils, small bodies of revolution, straight and swept untapered finite-span wings of varying span in a tunnel with a height-to-width ratio of $1/\sqrt{2}$. The calculations were done by the methods of line and point sources and sinks; the swept wing was represented by a line doublet arrangement.

Linear Theory of Boundary Effects in Open Wind Tunnels with Finite Jet Lengths. (*U.S., N.A.C.A., Technical Note No. 1826*, March, 1949.) S. Katzoff, Clifford S. Gardner, Leo Diesendruck, and Bertram J. Eisenstadt. *U.S., N.A.C.A., Report No. 976*, 1950. 37 pp., illus. 17 references. Superintendent of Documents, Washington. $0.30.

Investigation of Operating Pressure Ratio of a Supersonic Wind Tunnel Utilizing Distributed Boundary-Layer Suction in Test Section. C. B. Cohen and A. S. Valerino. *U.S., N.A.C.A., Research Memorandum No. E50H04*, November 1, 1950. 39 pp., illus. 1 reference.

Investigation at $M = 2.0$ in the N.A.C.A. 3.84- by 10-in. supersonic tunnel to assess boundary-layer removal by continuous suction as a means of reducing separation losses. The suction was accomplished through two compartmented walls of a constant-area extension of the test section which were covered with a smooth-surface screen.

NACA Tunnels Bare Secrets of Transonic; New Design of Test Sections for First Time Permits Lab Probing of Mach .8–1.3 Zone. Alexander McSurely. *Aviation Week*, Vol. 54, No. 22, May 28, 1951, pp. 13, 14, illus.

Experiments on Air Flow in the 7-Foot Open-Jet No. 1 Wind Tunnel and Application to Wind-Tunnel Design. V. M. Falkner and H. L. Nixon. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2484*, 1951 (January 31, 1944). 10 pp., illus. 5 references. British Information Services, New York. $0.50.

Investigation of irregularities in pitch and yaw in the working section; improvements in design and technique; features that require much investigation in the early design stages; measurement of wind direction.

The Use of a Potential Flow Tank for Testing Axi-Symmetric Contraction Shapes Suitable for Wind Tunnels. A. W. Babister, W. S. D. Marshall, G. M. Lilley, E. C. Sills, and S. R. Deards. *College of Aeronautics, Cranfield, England, Report No. 46*, April, 1951. 30 pp., illus. 7 references. 5*s*.

Design details of the water tank, probes, and related electronic equipment; model description and construction; experimental procedure, calculations of velocity distributions, and accuracy. Contraction ratios of the tests were approximately 7:1.

Effect of Size and Spectral Purity of Source on Fringe Pattern of the Mach-Zehnder Interferometer. F. D. Bennett. *Journal of Applied Physics*, Vol. 22, No. 6, June, 1951, pp. 776–779. 4 references. Results of a quantitative investigation of the intensity pattern, considering only an ideal interferometer that produces fringes perpendicular to the plane of centers of the reflecting elements.

Interferometer with Large Working Field Utilizing Schlieren Optics. Donald R. Buchele and Pierce B. Day. *U.S., N.A.C.A., Research Memorandum No. E50J27*, January 3, 1951. 17 pp., illus. 4 references.

Conversion of the optical system of a 24-in. diameter, two-mirror schlieren apparatus to an interferometer. Interference photographs were taken with the instrument in the N.A.C.A. 18- by 18-in. supersonic tunnel. The conversion unit can be operated with any schlieren system.

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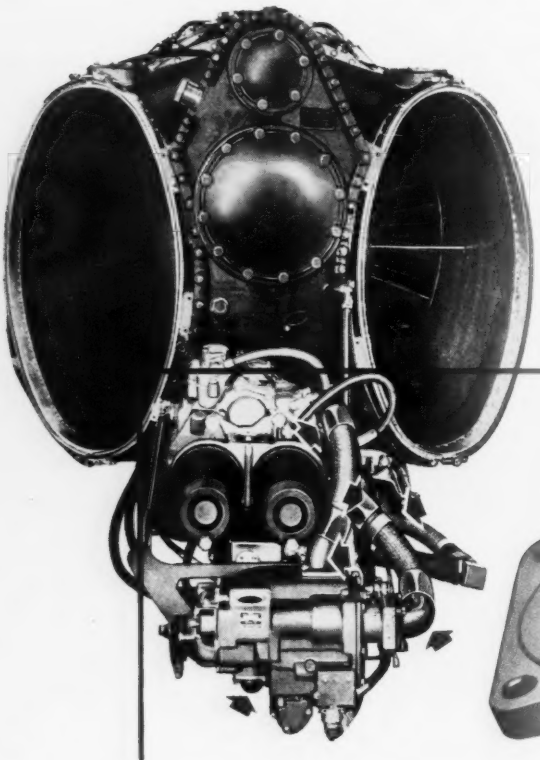

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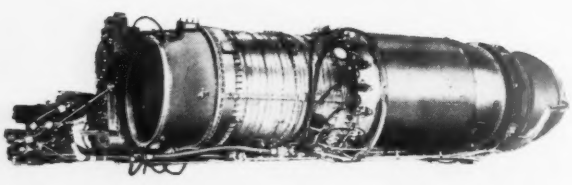

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Aeronautical Reviews — BOOKS

Advanced Fluid Dynamics and Fluid Machinery

By R. C. Binder. New York, Prentice-Hall, Inc., 1951. 426 pp., figs. $8.00.

Those who prize Professor Binder's earlier book, *Fluid Mechanics*, will be pleased to find in the author's *Advanced Fluid Dynamics and Fluid Machinery* the same simple and direct approach used even more effectively in the treatment of special or advanced topics of fluid dynamics. Engineering intuition is applied skillfully in formulating essential aspects. Relationships established by analysis are illustrated aptly by simple graphic presentation. Because of these characteristics, the book should be of great practical utility both as a text for the student and as a source of information for the engineer in practice.

The book has three parts, the first of which deals with the steady flow of a compressible fluid without and with heat transfer, and with turbulent energy dissipation and boundary-layer flow.

The second part treats of Fluid Mechanics—namely; axial-flow and centrifugal fans, pumps, and compressors; fluid couplings; and jet pumps. In the third part, selected fields of fluid mechanics, such as potential flow, two-dimensional compressible flow, and viscous flow are treated. As a contribution of special significance, a chapter is devoted to unsteady flow and fluid vibrations in such instances of engineering interest as water hammer, pulsations in engine induction systems, surging of compressors, and noise. This latter treatise, written on the level of undergraduate engineering instruction, may be found to answer a need that has assumed increased urgency in recent years.

The book is intended, as Professor Binder states in the introduction, to bridge the gap between the usual first treatment of fluid mechanics and the level of treatment of present problems in the engineering literature. In a number of instances the text is proof that this objective has been achieved, notably in the systematic presentation of high-velocity compressible flow. In other instances—e.g., the treatment of turbulent friction losses in pipes—it appears that too little space is devoted to the treatment of the nature of turbulent flow. Consequently, the student would find it difficult to conceive the logic that serves to establish this important law unless he were lead by the list of Selected References appended to each chapter to consult the source material. These well-chosen references are considered a valuable and essential part of the book.

Part II, dealing with Fluid Machines, fills nearly a third of the book. It includes descriptive material on diverse subjects such as hydraulic turbines and automotive torque converters, but certain essential basic relationships, such as Euler's hydrodynamic equation, though presented in general form elsewhere in the text, are not applied to turbomachines. This is one reason why the treatment of such topics as radial equilibrium of flow and energy transfer in turbomachine rotors appears elementary.

Considerably more space than is usual in first texts is devoted to mathematical analysis, especially in Part III. Fourier Series, Hyperbolic Functions, and Complex Quantities are introduced where needed, generally by enumeration of some of their properties, and immediately applied to the engineering problem under consideration. This method has merits for teaching since the student's interest is captured. However, it does not always convey the proper perspective. One instance is the treatment of stream function and velocity potential without adequate emphasis on the property of orthogonality of functions of a complex variable.

The selected topics treated in Part III serve to establish a reading knowledge (with the aid of a vocabulary) of the language of mathematics. Before mathematics can be used safely as a tool, however, it seems that careful study of the mathematical monographs listed in the Selected References is essential.

The above considerations demand attention in appraising a book intended not merely as an avenue toward the understanding of advanced fluid dynamic processes but also as a tool in the competent solution of engineering problems.

Professor Binder's new book undoubtedly will be effective in spreading appreciation of the significance of advanced fluid dynamics among engineers.

JOHN R. WESKE
Professor,
The Johns Hopkins University

Technical Libraries

Their Organization and Management. Prepared by the Science-Technology Division, Special Libraries Association. Lucille Jackson, Editor. New York, Special Libraries Association, 1951. 202 pp., diagrs. $6.00.

This pioneering book is the first American publication to describe in convenient form the duties, organization, and operation of the special technical library. It is based upon the experience of several thousand technical librarians who are predominantly employed by industrial concerns. However, the practices described apply equally to technical libraries in government agencies, professional societies, research institutions, trade associations, universities, and departments in public libraries.

The first four chapters are perhaps of direct interest to management, for they deal with organization, the duties and qualifications of the staff, the budget, and physical layout and equipment. Typical organization charts, job descriptions, costs for salaries and equipment, and floor plans make the presentation clear and brief. The excellent lists of references indicate where more detailed discussions are available.

Chapters 5 through 11 deal with operational details on methods for the dissemination of information, indexing, and the acquisition of material. Perhaps these chapters are of more direct interest to those whose job it is to carry out the directives that are implicit in the organization and job descriptions presented earlier. Nevertheless, this material is presented for

For information on I.A.S. Library Service Facilities, see page 65

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

those interested in establishing technical libraries as well as those now operating them, and management people can find out here what the library staff will do or will want to do for the best return on the invested dollar.

The final chapter, on methods of interpreting the services of the technical library in relation to the organization as a whole, may again be of direct interest to management. Selected lists of basic reference publications and specimen subject-field bibliographies are included in an appendix of 40 pages. These furnish good introductions to the basic literature of 19 technical fields, such as aeronautics, explosives, nonferrous metals, plastics, and rubber.

The many unsolved problems that are being worked on in the technical-library field are necessarily not suitable for discussion in a practical manual of this kind. For example, the available readers for microreproductions are described, but the universal portable reader cannot be described because it is not yet on the market. The Contoura camera is mentioned, but the full use of the camera in technical library operation is still being explored. This is true of the electronic copying "pencil," and various calculators and selectors.

Many problems connected with the distribution and processing of unpublished research reports are yet unsolved, and research has yet to produce cheaper, quicker, and more effective indexing. Nobody knows the answers to these problems, which are of considerable concern to all serious workers in technical libraries, but the available answers are to be found in *Technical Libraries*. It should be indispensable to the experienced as well as the inexperienced librarian, to the executive who always wondered what these people do, and to the executive who would like to read up on what his competitors are doing.

MAURICE H. SMITH
Librarian, I.A.S.

Book Notes

AERONAUTICS, GENERAL

Verslagen en Verhandelingen (Reports and Transactions), Vol. 15, 1949. Amsterdam, Nationaal Luchtvaartlaboratorium (National Aeronautical Research Institute), 1950. Various paging.

Contents: F.28, Gust Load Coefficients for Wing and Tail Surfaces of an Aeroplane, J. H. Greidanus and A. I. Van de Vooren. F.33, Loads on Wing and Tail Surfaces of an Aeroplane Due to a Sinusoidal Gust Wave, A. I. Van de Vooren. F.45, Proposal for an Airworthiness Requirement Referring to Symmetrical Gust Loads, J. H. Greidanus and A. I. Van de Vooren. F.35, A One-Parameter Method for the Calculation of Laminar Boundary Layers, R. Timman. M.1230, Reflections on Yielding and Aging of Mild Steel, J. H. Palm. S.341, Experimental Investigation of the Post-Buckling Behaviour of Flat Plates Loaded in Shear and Compression, A. Van der Neut and W. K. G. Floor. S.346, The Elastic Overall Instability of Sandwich Plates with Simply-Supported Edges, F. J. Plantema and A. C. De Kock. S.347, Load Distribution and Relative Stiffness Parameters for a Reinforced Flat Plate Containing a Rectangular Cut-Out Under Plane Loading, L. S. D. Morely. S.362, Load Distribution and Relative Stiffness Parameters for a Reinforced Circular Cylinder Containing a Rectangular Cut-Out, L. S. D. Morley and W. K. G. Floor. V.1543, Drawing Sphere for Analysis of Flight Test Results, S. Wynia and L. R. Lucassen. V.1547, The Effect of a Spring Tab Elevator on the Static Longitudinal Stability of an Aeroplane, A. J. Marx and J. Buhrman.

The MacArthur I Know. George C. Kenney. New York, Duell, Sloan and Pearce, 1951. 264 pp., illus. $2.75.

General Kenney begins with the statement that he is a MacArthur man and has written neither an attack on him nor a glamorized portrait. The account sticks closely to his personal knowledge of MacArthur, and the greater part of the book is concerned with the period between July, 1942, and the Japanese surrender in 1945, when the author commanded the Allied air forces in the Southwest Pacific under MacArthur. The result is a document of considerable historical value, a useful and timely by-product of the author's previous book, *General Kenney Reports*.

AIR TRANSPORTATION

Commercial Air Transportation. John H. Frederick. 3rd Ed. Chicago, Richard D. Irwin, Inc., 1951. 473 pp., illus., diagrs. $6.65.

This text was last revised in 1946. The present edition has been largely rewritten and rearranged, and the number of chapters reduced to produce a more compact book. The opening chapter deals with the present status of transport aircraft, and the following two chapters on Airports and Airways and Commercial Air Carriers combine several chapters of the previous edition. There are five chapters on Federal regulation, and the final seven chapters deal with air-line organization, financing, public relations, and particularly with passenger and cargo development and operations. There is a bibliography of about 100 titles. Appendixes include a historical review, a digest of the Civil Aeronautics Act of 1938 as amended, and a discussion of the International Civil Aviation Organization and the International Air Transport Association. The author is a Professor of Transportation and Foreign Trade at the University of Maryland.

ELECTRONICS

Pulse Techniques. Sidney Moskowitz and Joseph Racker. New York, Prentice-Hall, Inc., 1951. 300 pp., illus., diagrs. $6.65.

Readers with an electrical engineering background will find this textbook useful for the analysis and design of circuits for the transmission and utilization of pulses. Mathematical transform methods are developed in an early chapter on Transient Response of Linear Networks. The discussion proceeds into the pulse response of linear networks, followed by descriptions and design principles of frequently used nonlinear networks. The final chapters cover pulse-measurement methods and the design of communication systems and air navigation equipment using pulses. The authors are associated with the Federal Telecommunications Laboratories, Inc.

Synthesis of Electronic Computing and Control Circuits. Staff of the Computation Laboratory, Harvard University. Cambridge, Mass., Harvard University Press, 1951. 278 pp., illus., diagrs. $8.00.

In this volume, mathematical methods are presented systematically for the investigation of the functional behavior of electronic control circuits. A general algebraic approach is used. Vacuum-tube operators, switching functions of two and three variables and of n variables, and minimizing charts are discussed in the first chapters. Pyramids and Rectangles; Multiple-Output Circuits; Triggers, Rings, and Digit Counters; Time Variables; Rectifiers; Coding Systems; Adders and Accumulators; and Multipliers are discussed in succeeding chapters. Tables of input inversions, input rearrangements, and the switching functions of four variables are included in an appendix. The results as presented were developed under an Air Force contract with Harvard University.

Electromagnetic Problems of Microwave Theory. H. Motz. London, Metheun & Co., Ltd.; New York, John Wiley & Sons, Inc., 1951. 184 pp., diagrs. $2.00.

This balanced account, illustrating methods of analysis of wide applications, is intended for those having a basic knowledge of electromagnetism. Velocity modulation, mode selection in cavity magnetrons, field relations in waveguides, the problem of feeding a rectangular guide by means of a straight antenna, and the theory of discontinuities in waveguides are among the topics discussed. There is a separate chapter on a numerical method capable of wide applications. The author is now Research Associate at the Microwave Laboratory of Stanford University and formerly was engaged in research in England. A bibliography of about 40 books and articles is included.

EQUIPMENT

ELECTRIC

The Nature of Polyphase Induction Machines. Philip L. Alger. New York, John Wiley & Sons, Inc., 1951. 397 pp., diagrs. $7.50.

The purpose of the author is to give the reader understanding and visual perception of the behavior of this simplest and most widely used of electric machines and some familiarity in the numerical prediction of its behavior. Equivalent circuits, harmonic analysis, rotating fields, and energy-flow concepts are discussed first, and formulas are derived for numerical circulation of the simplest aspect of each phenomenon. Secondary aspects are considered separately, enabling the overall result to be obtained as the sum of a converging infinite series. The author is Consulting Engineer with the Small and Medium Motor Divisions of the General Electric Company.

FUELS & LUBRICANTS

Fuels and Combustion Handbook. Edited by Allen J. Johnson and George H. Auth. New York, McGraw-Hill Book Company, Inc., 1951. 915 pp., illus., diagrs. $12.50.

The aim of the editors is to provide factual data on the entire range of commercial fuels, arranged in convenient form for reference by practicing engineers, students, and others interested in the selection and use of fuels and fuel utilizing equipment. Solid Fuels, Liquid and Gaseous Fuels and Miscellaneous Sources of Heat and Power, Combustion, Selection of a Fuel, Preparation of Coal for Utilization, and Fuel Handling Methods are the titles of the first six sections. Section 7 (6 chapters) deals with The Transfer and Generation of Heat, and the final chapter is concerned with Boiler Measurements and Tests. Sources are indicated for all the data presented, and there is an excellent index. The senior editor is a consulting mechanical engineer, and Professor Auth teaches mechanical engineering at Villanova College.

MAINTENANCE

Proceedings, 1951 Annual Engineering and Maintenance Conference. Washington, Air Transport Association of America, 1951. 863 pp. $17.50.

This is a verbatim report of the discussions of this valuable annual conference, attended by 677 representatives of air lines; air-frame, engine,

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MATERIALS

The Principles of Rheological Measurement, British Rheologists' Club, Report of General Conference, Bedford College, University of London, October, 1946. London, Thomas Nelson and Sons, Ltd., 1949. 214 pp., illus., diagrs. 30s.

Contents: Measurements of the Rheological Properties of Lubricating Greases, E. G. Ellis. Viscometers for Soft Solids, J. W. Amner and J. F. T. Blott. Geometry of Rheological Phenomena, K. Weissenberg. The Practical Application of Dr. Weissenberg's Proposal of a "Rheogoniometer," S. M. Freeman. Some Principles Involved in the Measurement of Thixotropic Materials, Henry Green. Pastes and Doughs, G. W. Scott Blair. Hardness Testing of the Rubber-Like State, J. M. Buist. The Measurement of Stress Relaxation of Unvulcanized Rubber by Means of the Mooney Shearing-Disc Viscometer, C. M. Blow and J. R. Schofield. The Anisotropic Elastic Properties of Wood, Wilfred W. Barkas. Mechanical Testing of Solids, E. Orowan. The Meaning and Use of Certain Rheological Terms, L. R. G. Treloar.

Viscosity and Plasticity. E. N. daC. Andrade. New York, Chemical Publishing Company, Inc., 1951. 82 pp., diagrs. $2.25.

These three lectures were given under the auspices of the London Section of the Oil and Colour Chemists' Association. The lectures deal with The Nature and Theories of Liquid Viscosity; The Flow of Simple Liquids, Suspensions, and Gels; and The Flow of Solids. An index of names and subjects is included. The author is Quain Professor of Physics at the University of London.

Engineering Metallurgy. Alexander P. Gwiazdowski. Appleton, Wis., C. C. Nelson Publishing Co., 1950. 247 pp., illus., diagrs. $4.00.

The objectives of this text and practical reference book are to provide discussions of principles, selection of materials, selection of heat treatments, and data on engineering specifications. Basic metallurgical information is given on the characteristics of commercially important metallic elements and their alloys. About 40 tables are included. The author is a Professor of Industrial Engineering at Tri-State College.

American Society for Testing Materials, Proceedings, Vol. 50, 1950. Philadelphia, The Society, 1951. 1,490 pp., diagrs. $12

In addition to the reports of committees on ferrous and nonferrous metals, ceramics, fuels, oils, adhesives, plastics, and other materials, this volume contains a number of technical papers.

Partial contents: **The Influence of Strain Rate on Some Tensile Properties of Steel**, D. S. Clark and P. E. Duwez. **The Influence of Specimen Dimension and Shape on the Results in Tension Impact Testing**, D. S. Clark and D. S. Wood. **Some Effects of Austenitic Grain Size and Metallurgical Structure on the Mechanical Properties of Steel**, G. M. Sinclair and T. J. Dolan. **Effect of Variations in Notch Acuity on the Behavior of Steel in the Charpy Notched-Bar Test**, N. A. Kahn, E. A. Imbembo, and F. Ginsberg. **The Fatigue Strength of Steel Through the Range from ½ to 30,000 Cycles of Stress**, M. H. Weisman and M. H. Kaplan. **Effects of Grinding and Other Finishing Processes on the Fatigue Strength of Hardened Steel**, L. P. Tarasov, and H. J. Grover. **Effect of Chromium Plating on the Endurance Limit of Steels Used in Aircraft**, Hugh L. Logan. **Fatigue Notch-Sensitivities of Some Aircraft Materials**, H. J. Grover. **Effects of Anodic Coatings on the Fatigue Strength of Aluminum Alloys**, G. W. Stickley and F. M. Howell. **Effect of Various Treatments on the Fatigue Strength of Notched S-816 and Timken 16-25-6 Alloys at Elevated Temperatures**, W. E. Jones, Jr., and G. B. Wilkes, Jr. **Welding Characteristics of Open Hearth and Bessemer Seamless Steel Pipe**, A. B. Wilder, W. B. Kennedy, and F. W. Crouch. **Welds Between Dissimilar Alloys in Full-Size Steam Piping**, R. U. Blaser, F. Eberle, and J. T. Tucker, Jr. **Some Considerations in the Jointing of Dissimilar Metals for High-Temperature High-Pressure Service**, O. R. Carpenter, N. C. Jessen, J. L. Oberg, and R. D. Wylie. **Hardening of Austenitic Stainless Steels by Mechanical Working at Sub-Zero Temperatures**, N. A. Ziegler and P. H. Brace. **Hardened Alloy Steel for Service Up to 700°F.**, G. V. Smith, W. B. Seens, and E. J. Dulis. **Effect of Temperatures on the Mechanical Properties, Characteristics, and Processing of Austenitic Stainless Steels**, V. N. Krivobok and A. M. Talbot. **Effect of Rate of Strain on the Flow Stress of Gas Turbine Alloys at 1200° and 1500°F.**, M. J. Manjoine. **The Selection of a Limited Number from Many Possible Conditioning Treatments for Alloys to Achieve Best Coverage and Statistical Evaluation**, J. M. Cameron and W. J. Youden. **Magnesium-Cerium Wrought Alloys for Elevated-Temperature Service**, K. Grube, J. A. Davis, and L. W. Eastwood. **Magnesium-Cerium Cast Alloys for Elevated-Temperature Service**, K. Grube and L. W. Eastwood. **Aluminum-6 Per Cent Magnesium Alloys for Elevated-Temperature Service**, L. W. Eastwood, Webster Hodge, and C. H. Lorig. **Tensile Properties of Some Aircraft Structural Materials at Various Rates of Loading**, Richard F. Klinger. **Combined Tension-Torsion Creep-Time Relations for Aluminum Alloy 2S-O**, Joseph Marin, J. H. Faupel, and L. W. Hu. **The Reverting of Hard-Drawn Copper to Soft Condition Under Variable Stress**, John N. Kenyon. **The Forming Characteristics of Beryllium Copper Strip**, John T. Richards and Ellsworth M. Smith. **Chromium-Base Alloys**, W. L. Havekotte, C. T. Greenide, and H. C. Cross. **Spray Testing with Natural**

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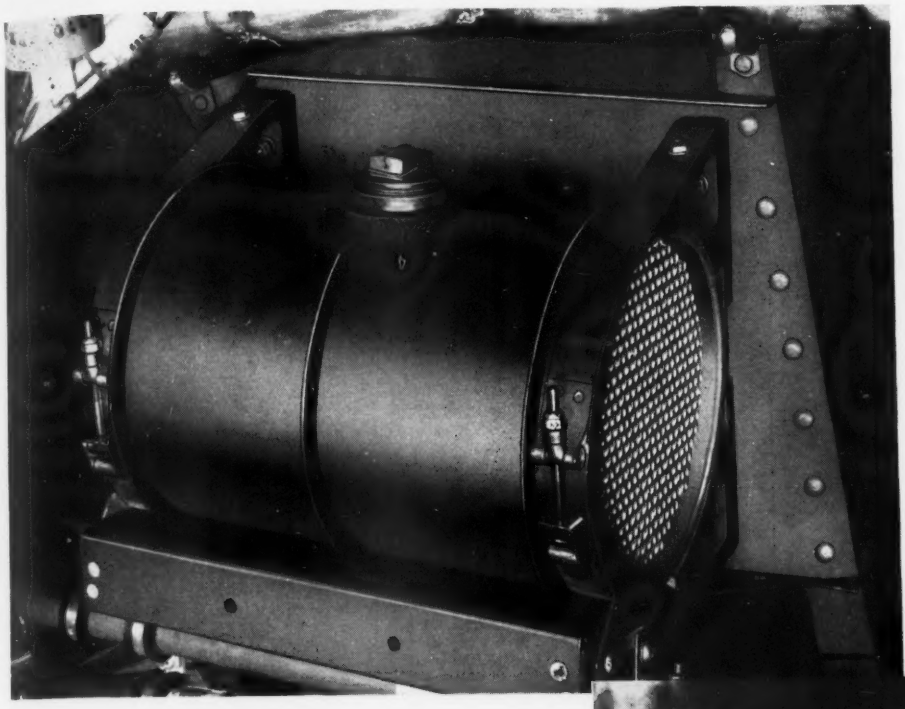

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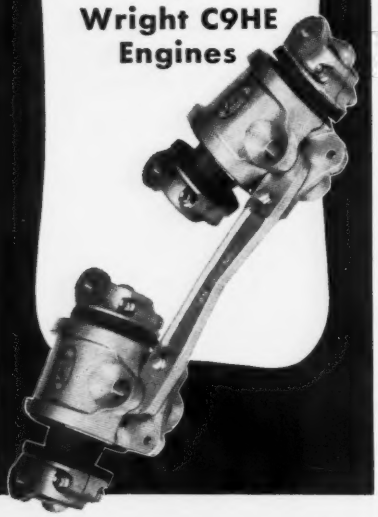

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Materials Buying Manual. Harold A. Knight. New York, Conover-Mast Publications, Inc., 1951. 340 pp. $4.50.

About 172 materials are covered in this reference book written for purchasing agents and business and industrial executives. Physical, chemical, and geographical data on sources, brief steps in preparation and manufacture, grades, chief uses, shipping data, price ranges over a typical period, and sometimes production statistics are included. Typical longer articles deal with aluminum, nickel, nylon, plastics, plywood, and steel (alloy, carbon, stainless, and tool steels). Typical treatments, two or three pages in length, include abrasives, beryllium, powered metal parts, titanium, and tungsten. There is an index.

MILITARY AVIATION

Civil Defense in Modern War. Augustin M. Prentiss. New York, McGraw-Hill Book Company, Inc., 1951. 429 pp., illus., diagrs. $6.00.

This excellent book discusses modern air warfare, civil air defense, and organization for civil air defense. It is designed as a text on the protection of the civil population against atomic, bacterial, and chemical warfare and is based largely on World War II experience and official open documents. There is a 9-page bibliography of U.S. and foreign government publications, books, and articles. General Prentiss presents a great deal of material in detail and with clarity, summarizing the existing knowledge of air weapons and means of protection against them, including both practical steps and preparatory organization.

L'Arme Aéroportée, Clé de la Victoire? Lt. Col. Rocolle. Paris, Charles-Lavauzelle & Cie., 1948. 2 Vols.; 192, 243 pp.; maps, diagrs. Vol. 1, 300 fr.; Vol. 2, 325 fr.

This is a history and analysis of air-borne troop operations, beginning with the Russian experiments of 1930 with parachute troops and ending with the French action at Hoa-Binh, French Indo-China, in April 1947. Most of the actions described occurred during World War II. Axis operations reached their climax in 1940, when eight actions were carried out, and Allied operations reached their highest point in 1942, 1943, and 1944, eleven actions taking place in 1944. The discussion covers technical development and the beginnings of air-borne action in the early 1930's, proceeding into special missions, air commandos, and the organization and characteristics of air-borne divisions. The second volume takes up strategic and tactical questions. The author's conclusion is that air-borne divisions are here to stay and should be increased.

ORDNANCE & ARMAMENT

Internal Ballistics. Gt. Brit. Ministry of Supply. London, H.M. Stationery Office, 1951. 311 pp. 25s.

This cooperative work was undertaken by an editorial panel of the Scientific Advisory Council of the Ministry of Supply, functioning through its

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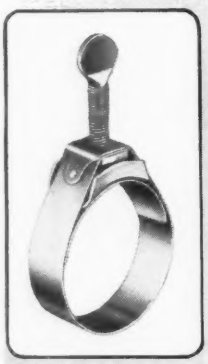

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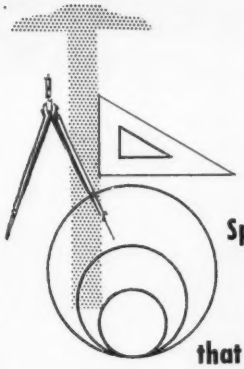

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Ballistics Committee and later through the Weapon Research Committee. Its purpose is to coordinate recent research in the subject and give an up-to-date account of it. The first three chapters deal with propellants, including their thermochemistry and burning. The discussion of combustion is continued with chapters on The Form Function and Combustion at Constant Volume, The Energy Equation and The Equation of Motion of the Projectile are next taken up, followed by discussions of the Hunts-Hinds System of Internal Ballistics and other methods for a linear law of burning, and a chapter on solutions for a nonlinear law of burning. The final half of the book is concerned with projectile-velocity measurement; pressure measurement in closed vessels and guns; methods of propellant proof; statistical methods for internal ballistics; and a review of research in Great Britain, Germany, and the United States on the manner and rate of burning of the propellant, the pressure gradient in the propellant gas, and the resistance to the forward motion of the projectile. There is a bibliography of more than 340 references, including a number of reports of the Armament Research Department, the Advisory Council on Scientific Research, and other research agencies.

PARACHUTES

Go! Le Manuel du Parachutiste. William Meligne. Paris, Charles-Lavauzelle & Cie., 1950. 139 pp., illus. 300 fr.

This manual by a young Frenchman was written for future paratroopers and describes the methods and special devices used in their ground training, the equipment and its working, the jump, and the descent. There is a final chapter on special jumps—e.g., at night or over water. The opening chapter is a brief history. The book is well illustrated with photographs and drawings.

POWER PLANTS

Internal-Combustion Engines. Lester C. Lichty. 6th Ed. New York, McGraw-Hill Book Company, Inc., 1951. 598 pp., diagrs. $7.00.

This textbook was first published in 1915 and was last revised in 1939. The present edition is a thorough revision including much new material; some older material has been eliminated. The Lenoir and Brayton cycles have been added because of the development of gas-turbine, jet, and rocket engines. The discussion of fuels, mixture formation, combustion, and combustion knock has been extended, and its applications include jet engines and rockets. New thermodynamic data apply to the hydrogen-oxygen rocket, and the rocket reaction is used to illustrate the principles of dissociation. Other new material includes the Lewis combustion diagram for gas-turbine analysis, data on water injection, combustion-chamber design, and fuel-injection systems. The author is the Robert Higgin Professor of Mechanical Engineering at Yale University.

Aircraft Engines of the World, 1951. Paul H. Wilkinson. New York 14, The Author, 225 Varick St., 1951. 324 pp., illus. $12.

This new edition of a standard reference book includes 57 complete standardized specifications for main gas-turbine power plants, of which 18 are new. These include 5 American, 1 British, 1 Belgian, 3 French, 1 Swedish, and 2 Russian turbojets, and 5 American turbojets using afterburners. Comparative tables give data on 47 turbojets (7 using afterburners) and 12 turboprops. A new feature is a tabulation of more than 100 airplanes representing the latest military commercial, personal, and research types that use jet engines. The reciprocating-engine part includes 77 complete standardized specifications of engines, including 11 that are new. Among these are the Pratt & Whitney R-4360 C-Series, the Wright Turbo-Compound 18R-3350 and 9R-1820, and the Russian ASH-21 and ASH-90.

Thermodynamique de la Turbine à Gaz. Paul Chambadal. Paris, Hermann & Cie., 1949. 315 pp., diagrs. 1,700 fr.

The author's aim is to present systematically the functioning of the gas turbine from the thermodynamic point of view. The evolution of

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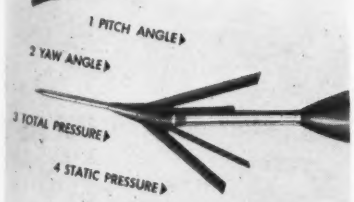

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the fluid in the turbine proper and in the compressor is considered; then the influence of the thermal cycle on the efficiency of the complete engine is considered. In four separate chapters, the cycle is considered with and without intermediate reheat and recovery of the heat of escaping gas. Others are concerned with the cycle with base pressure; combustion without an excess of air, and open, closed, and mixed circuits. Combinations of the gas-turbine cycle with other heat cycles and its use for the simultaneous production of work and heat or cold are discussed in the final two chapters. The author is an engineer associated with the Direction of les Études et Recherches d'Electricité de France.

PRODUCTION

Techniques of Plant Maintenance, 1951; Proceedings of the Technical Sessions, Sponsored by the American Society of Mechanical Engineers and the Society for the Advancement of Management, Cleveland, January, 1951. New York, Clapp & Poliak, Inc., 1951. 223 pp., diagrs. $6.00.

Forty papers on various aspects of factory maintenance are included in this volume. The general sessions cover inspection procedures, records and reports, training, maintenance costs and budgeting, incentive payment, painting and decorating, maintenance of floors, and sanitation, with one session on maintenance in small plants. Maintenance of electrical equipment, power plant and heating equipment, and lighting equipment were discussed in separate sessions; there are six papers on lubrication problems. Special problems of chemical, paper and paper-products, food processing, and metalworking plants are also discussed.

Proceedings of the Fourteenth Annual National Time and Motion Study and Management Clinic, Sponsored by the Industrial Management Society, Chicago, November 1, 2, and 3, 1950. Chicago, The Industrial Management Society, 1951. 104 pp., illus. $3.00.

Contents: What's New in Industrial Engineering? The Products of Sound Methods Engineering, C. W. Guyatt. Manufacturing Research—Genesis and Evaluation, J. W. Armour. The Union Is Here To Stay—Let's Learn To Live with It, E. H. Johnson. Employee Security Means a Lot—But It Isn't Everything, W. G. Caples. Labor's View of Negotiations, J. A. Beirne. Training Supervisors in Work Simplification, Herman A. Straus. Step-by-Step Application of Measured Day Work, R. C. Howell. What Are the Essentials To Make Preventive Maintenance Pay, M. Olchoff. How To Organize for Low Cost Maintenance, C. Lee Dryden. A Career in Industrial Engineering—A Panel Discussion. Job Evaluation and Merit Rating—A Panel Discussion. Philosophy Behind Contract Settlement, H. W. Anderson. Progress Through Motion Study and Better Methods, Stewart D. Martin and Elmer Braun. Good Layout Gives Low Cost Production, C. L. Nevitt. The Templet Versus the Model—Their Values, H. M. Alkire. Our Management and Employee Team Is Producing Results, Fred Maytag, II. Organization for Cost Reduction, W. J. Sneck. Work Factor As a Key to Cost Reduction, W. G. O'Brien. Selling Management on Materials Handling, John F. Roberts. Positioning Progress and Profits, D. W. Pennock. Work Simplification Is a Tool of Productivity—A Panel Discussion, with Allen H. Mogensen and Marvin E. Mundel. Industry's Responsibility for Peace, John E. O'Gara.

Production of Motor Vehicles. Henry M. Cunningham and William F. Sherman. New York, McGraw-Hill Book Company, Inc., 1951. 169 pp., illus., diagrs. $3.50.

This book was written for the Industrial College of the Armed Forces and for the several procurement and planning branches of the National Military Establishment. It is a semitechnical study of managerial techniques in planning, scheduling, and manufacturing a new model truck or automobile. The senior author is associated with the Munitions Board of the Defense Depart-

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REFERENCE WORKS

Molesworth's Handbook of Engineering Formulae and Data. Edited by Albert Peter Thurston. 34th Ed. London, E. & F. Spon, Ltd.; New York, The Macmillan Company, 1951. 1,672 pp., diagrs. $6.50.

This standard handbook, first published in 1862, was last revised in 1946. The present edition is larger by nearly 700 pages and has been completely rewritten. The first section is general and includes mathematical tables, conversion factors, mechanics, physical data, materials, explosives and ballistics, and British standards. The second section covers civil and general engineering; the third, mechanical engineering; and the fourth, electrical engineering. Aircraft materials, fuels, and lubricants are included in appropriate sections, and there are tables of standard atmosphere, properties of air, and properties of alloys, plastics, and other materials.

Pacific Coast and Inland Aviation Directory, 1951. Temple City, Calif., 3303 Tyler Avenue, Pacific Coast Aviation Publishing Company, 1951. 192 pp. $2.00.

About 100 pages of this useful directory are devoted to a complete listing of airports in Arizona, California, Oregon, and Washington. Flying data; names of personnel; and addresses of operators, dealers, and services available at each airport are included. Alphabetical indexes of airports in each state are provided. Alphabetical and classified lists are included of manufacturers, vendors and representatives of aircraft, parts, components, and supplies; distributors; air lines; insurance companies and agents; Federal and State Government agencies; and state associations.

RESEARCH

Costs, Budgeting, & Economics of Industrial Research; Proceedings of the First Annual Conference on Industrial Research, June 1951, Sponsored by the Department of Industrial Engineering, Columbia University. New York, King's Crown Press, Columbia University, 1951. 261 pp. $4.50.

Contents: Opening Address to the Conference on Industrial Research, Robert Teviot Livingston. The Philosophy and Economics of an Industrial Research Program, Lincoln T. Work. Sources and Cost of Capital To Finance Research and the Results of Research, Roland P. Soule. Exploratory Research, Paul D. V. Manning. The Design of an Integrated Research Program, James A. Stewart. Market Research and Development as a Function of Industrial Research, A. G. Ashcroft. Transition to Production, L. C. Kemp, Jr. On the Design of Simple Statistical Experiments, Robert E. Bechhofer. Experimental Method and the Statistical Design of Experiment, Sebastian B. Littauer. Measures of Variance and the Statistical Design of Experiments, Cuthbert Daniel. The Universities and Industrial Research, John R. Dunning. New Products and the Problem of the Sales Mixture: The Sales Mixture Chart, Raymond Villers. Research Cost Analysis and Project Evaluation, Edward Hartshore. Clinic session discussions are included on Definition of Industrial Research, Selling Research to Management, Project Selection and Review, The Research Advisory Committee, Evaluation of Working Projects, Evaluation of Research Results, Handling Unsolicited Ideas, Market Research, Transition to Production, Allocation of Expenses to Projects, Amortization of Cost-Reduction Projects, Charging for Technical Services, and Statistical Design of Experiments.

SCIENCES, GENERAL

MATHEMATICS

Fourier Transforms. Ian N. Sneddon. New York, McGraw-Hill Book Company, Inc., 1951. 542 pp., diagrs. $10.

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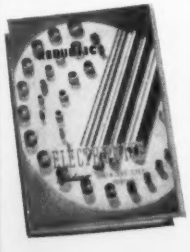

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Tables of the Bessel Functions of the First Kind of Orders Seventy-Nine Through One Hundred Thirty-Five. (Harvard University, Computation Laboratory, Annals, Vol. 14.) Cambridge, Mass., Harvard University Press, 1951. 614 pp. $8.00.

This book completes a 12-volume series, comprising Volumes III through XIV of the *Annals of the Computation Laboratory*, tabulating the Bessel Functions $J_n(x)$ for all integral n from 0 through 100 in the interval $0 \leq x \leq 100$, the first four functions to 18 decimal places and the remainder to 10 decimals. The original plan was extended to include the 10-decimal tables of $J_n(x)$ through $n = 135$ in the x-range specified, and, in addition a table of $J_n(x)$, $n = 0, \ldots, 135$ to close the interval. In the present volume, a 15-decimal table of $J_n(n)$ for integral values of n from 0 to 100 has been included.

Mathematical Solution of Engineering Problems. J. Jennings. London, E. & F. N. Spon, Ltd., 1951. 208 pp., diagrs. 25*s*.

The author's purpose is to provide the engineer and student with a volume between the elementary book and the advanced book using higher mathematics. The reader is required to know algebra and trigonometry, and the elements of differential and integral calculus. Approximations, nomograms, dimensional analysis, and statistical methods are discussed in separate chapters. Other chapters deal with Analysis of Experimental Data; Areas, Approximate Integration, Volumes, Centroids, Moments of Inertia; Linear Simultaneous Equations; Some Mathematical Problems Connected with Periodic Phenomena; and Problems Involving Fractions and Integral Numbers.

Contributions to the Theory of Games. Edited by H. W. Kuhn and A. W. Tucker. (Annals of Mathematics Studies, No. 24.) Princeton, N.J., Princeton University Press, 1951. 201 pp. $3.00.

The papers in this volume were prepared under contracts with the Office of Naval Research and The RAND Corporation. The first 11 papers constitute Part I, Finite Games; and the last 4 papers make up Part II, Infinite Games. In addition to the bibliography with each paper, there is a consolidated bibliography of about 150 references.

Contents: 1, The Elementary Theory of Convex Polyhedra, H. Weyl. 2, Elementary Proof of a Minimax Theorem Due to von Neumann, H. Weyl. 3, Basic Solutions of Discrete Games, L. S. Shapley and R. N. Snow. 4, Solutions of Finite Two-Person Games, D. Gale and S. Sherman. 5, Solutions of Discrete Two-Person Games, H. F. Bohnenblust, S. Karlin, and L. S. Shapley. 6, Solutions of Games by Differential Equations, G. W. Brown and J. von Neumann. 7, On Symmetric Games, D. Gale, H. W. Kuhn, and A. W. Tucker. 8, Reductions of Game Matrices, D. Gale, H. W. Kuhn, and A. W. Tucker. 9, A Simplified Two Person Poker, H. W. Kuhn. 10, A Simple Three-Person Poker Game, J. F. Nash and L. S. Shapley. 11, Isomorphism of Games and Strategic Equivalence, J. C. C. McKinsey 12, Operator Treatment of Minmax Principle, S Karlin. 13, On a Theorem of Ville, H. F. Bohnenblust and S. Karlin. 14, Polynomial Games, M. Dresher, S. Karlin, and L. S. Shapley. 15, Games with Continuous, Convex Pay-Off, H. F. Bohnenblust, S. Karlin, and L. S. Shapley.

General Homogeneous Coordinates in Space of Three Dimensions. E. A. Maxwell. Cambridge and New York, Cambridge University Press, 1951. 169 pp. $2.75.

This textbook is designed as a short introduction to algebraic geometry in space of three dimensions, preparing the reader for further study. Knowledge is assumed of the author's *Methods of Plane Projective Geometry Based on the Use of General Homogeneous Coordinates* (1946), to which this is a sequel. A number of examples illustrate the principles outlined. In the final chapter the elements of matrix algebra and the use of matrices are demonstrated. The author is a Fellow of Queens' College, Cambridge.

Practical Mathematics; Part 4, Trigonometry and Logarithms. Claude Irwin Palmer and Samuel Fletcher Bibb. 5th Ed. New York, McGraw-Hill Book Company, Inc., 1951. 192 pp., diagrs. $2.60.

This standard work was first published in 1913 and was last revised in 1941. New material, such as an article on the escribed circle, and new problems have been added, and corrections have been made. Sufficient work in logarithms is given in Chapter 1 to enable the reader to acquire a fair degree of skill in computations. The greater part of the book is devoted to trigonometry, with emphasis on direct applications to practical problems. The senior author was formerly Professor of Mathematics and Dean of Students at the Armour Institute of Technology, and Associate Professor Bibb teaches mathematics at the Illinois Institute of Technology.

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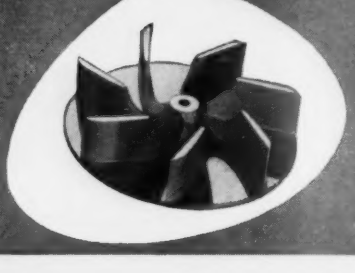

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Sound. W. Hall and O. M. Matthews. London, Edward Arnold & Company; New York, Longmans, Green & Company, 1951. 239 pp., illus., diagrs. $1.75.

This is a textbook of the preuniversity level, supported by practical experiments using the latest devices to illustrate principles. Full attention is given to wave theory, resonance, and ultrasonics, and there is a separate chapter on technical applications. Single harmonic motion and the cathode-ray oscillograph are discussed in an appendix. The authors are associated with King Edward's School in Birmingham.

Fundamentals of Atomic Physics. Saul Dushman. New York, McGraw-Hill Book Company, Inc., 1951. 294 pp., diagrs. $5.50.

This textbook, in the early chapters, covers the kinetic theory of gases, charge and mass of the electron, electronics, photoelastic effect, X-rays, the Bohr theory of the origin of spectral lines, electron configurations in atoms and the periodic arrangement of the elements, matter waves, and isotopes. The final two chapters (77 pages) discuss Nuclear Phenomena and Generators for Acceleration of High-Energy Particles. The opening chapter is a Brief History of Physics, which is followed by a brief mathematical introduction. Elementary calculus is necessary to the reader. The author is a Research Consultant to the General Electric Company.

A New Theory of Gravitation. Jakob Mandelker. New York, Philosophical Library, 1951. 25 pp., diagrs. $2.75.

The author's basic premise is that radiation is a manifestation of force directly opposed to gravitation. Gravitation is conceived as the correlated counterforce to radiation, holding matter together in accordance with the duality principle. A natural system of physical units is derived in the final chapter. The author is Assistant Professor of Mechanics at the Georgia Institute of Technology.

SPACE TRAVEL

Interplanetary Flight; An Introduction to Astronautics. Arthur C. Clarke. New York, L. Harper & Brothers, 1951. 164 pp., illus. $2.50.

The British edition of this book by the Assistant Secretary of the British Interplanetary Society was favorably reviewed in the AERONAUTICAL ENGINEERING REVIEW, September, 1950, page 77, by Alfred Africano, of the Rocket Department, Propeller Division, Curtiss-Wright Corporation. This review is quoted here in part.

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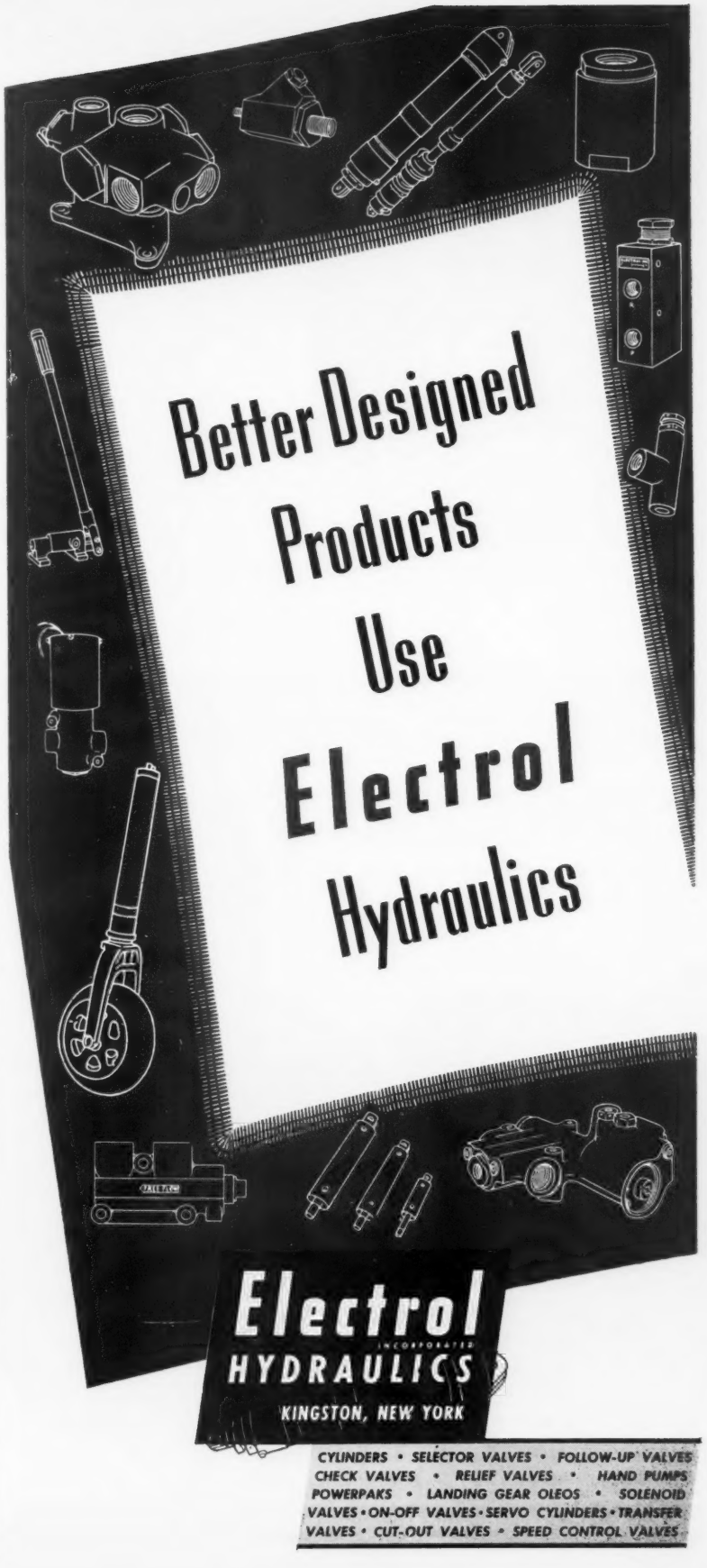

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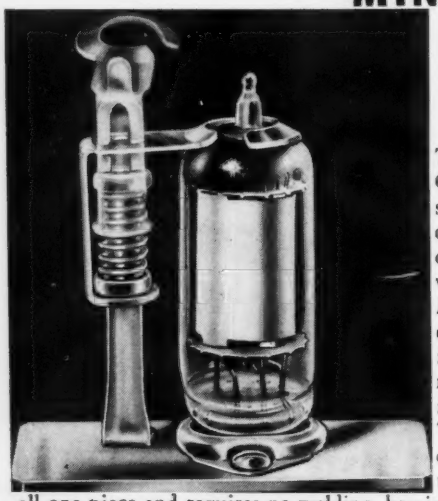

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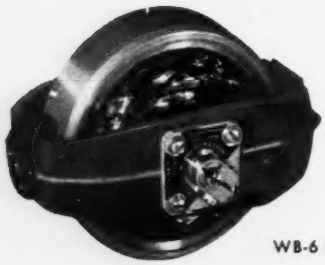

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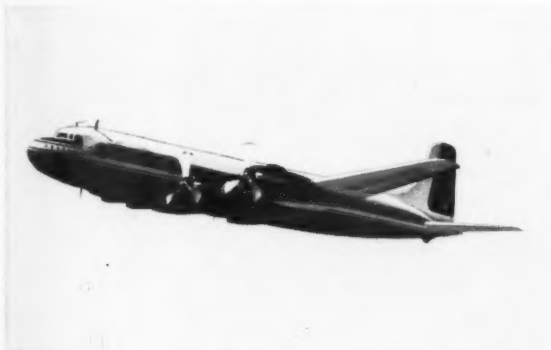

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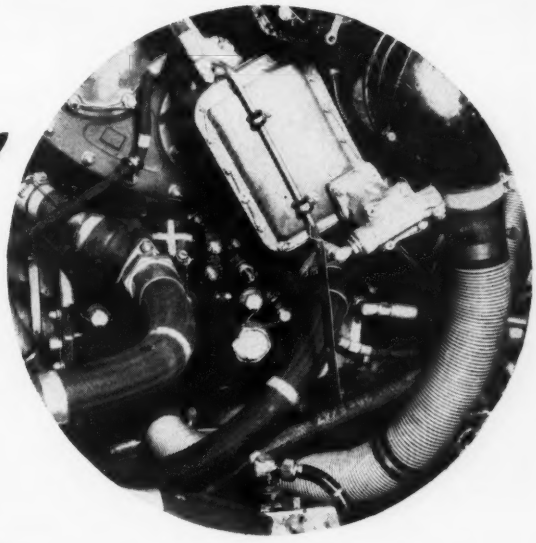

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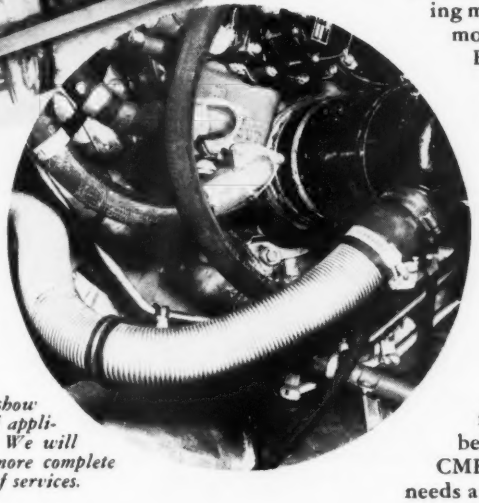

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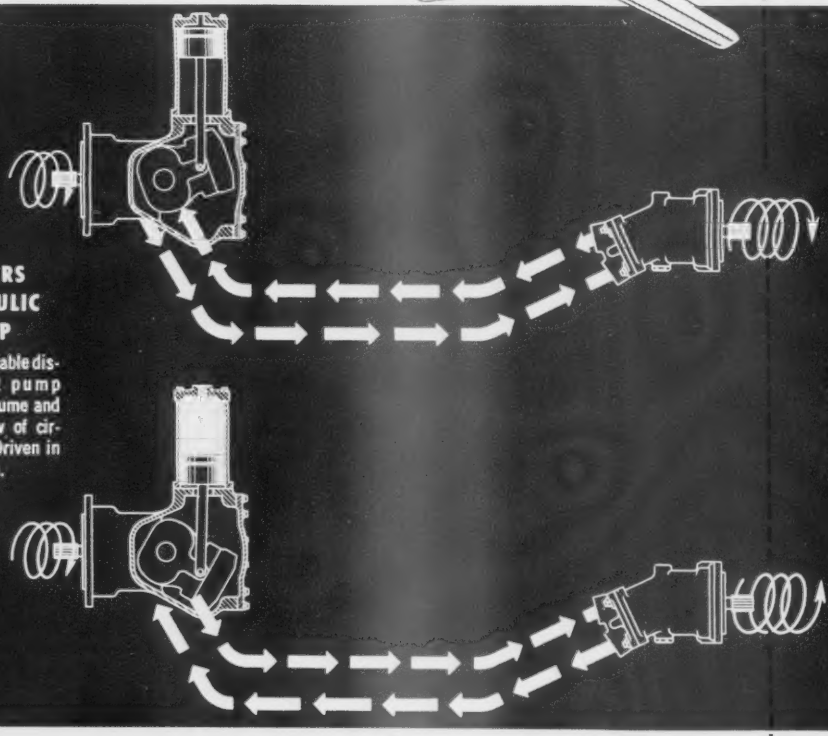

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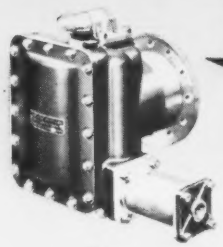

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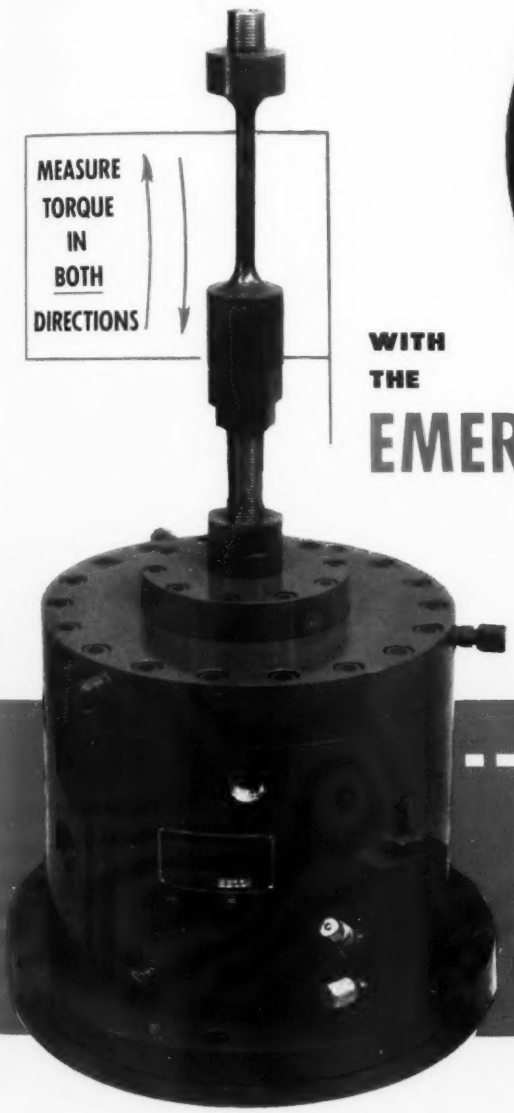

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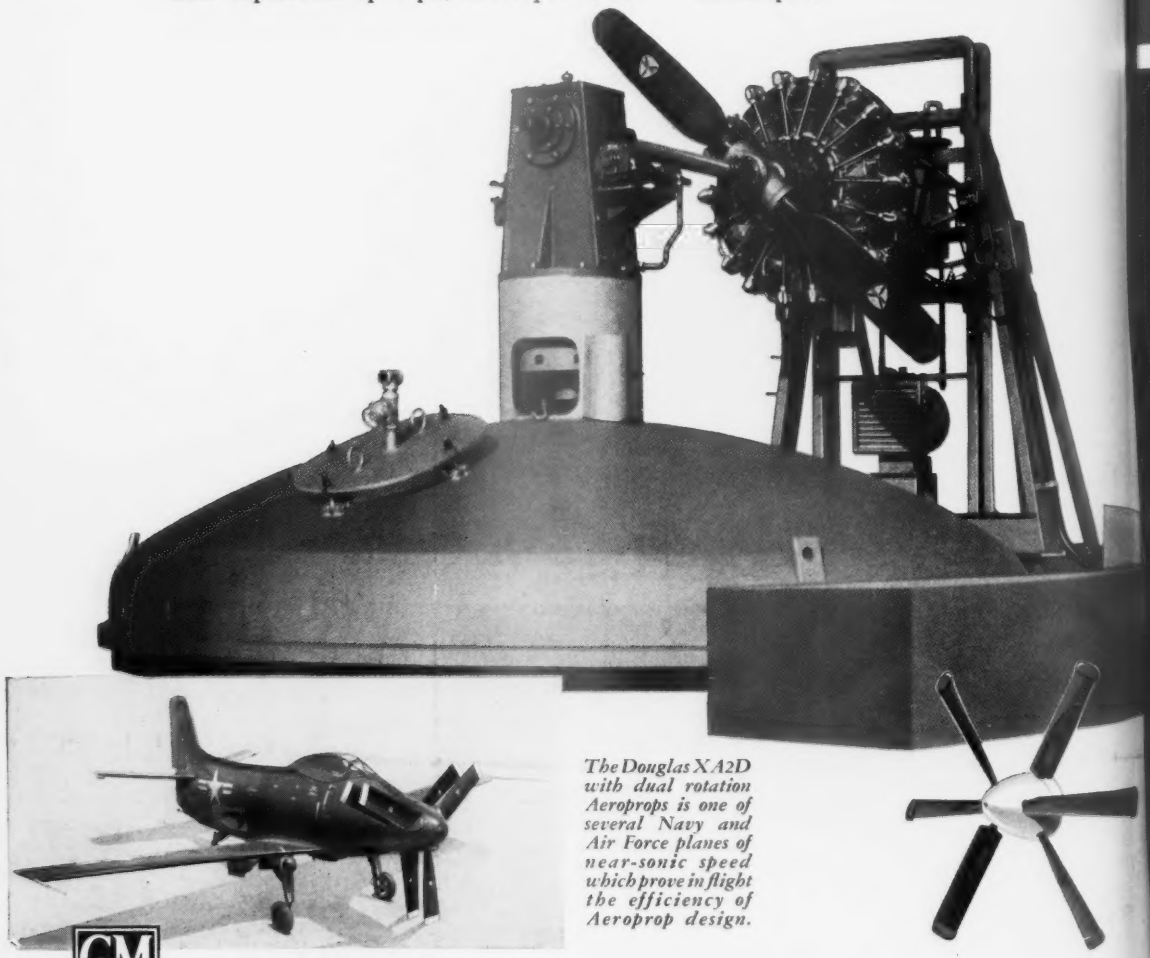

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